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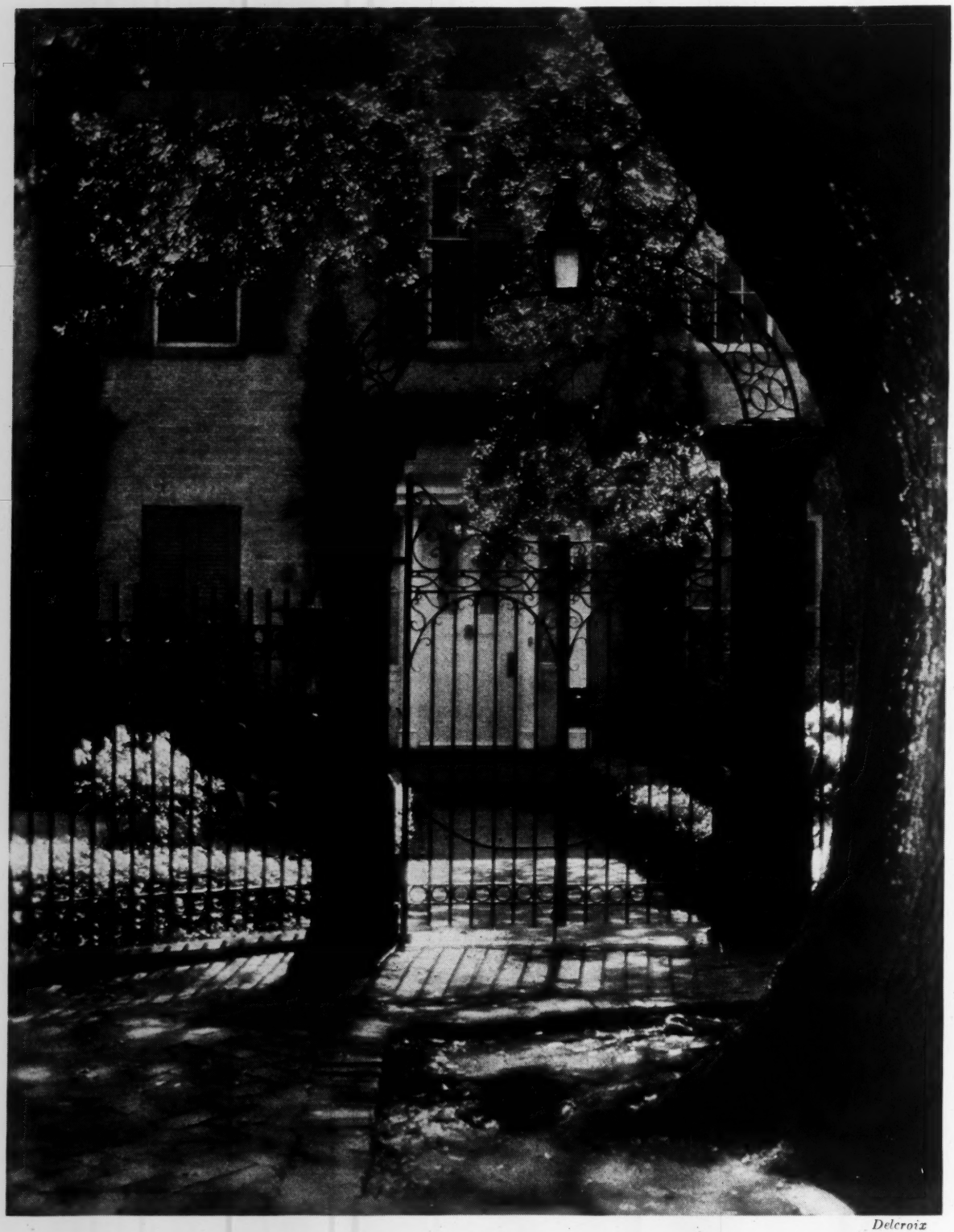

Delcroix

Picturesque Colonial Home in New Orleans

(*A.S.M.E. Spring Meeting at New Orleans, Feb. 23–25, 1939.* *See program on page 175 of this issue*)

VOLUME 61
No. 2

MECHANICAL ENGINEERING

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GEORGE A. STETSON, *Editor*

The Professional Ideal

UNDOUBTEDLY, if that delightful custom of toasts, which our British cousins retain, still prevailed in this country, William McClellan, presiding at the All-Engineers' Dinner in connection with the Nineteenth Annual Assembly of American Engineering Council, in the ballroom of the Mayflower Hotel, Washington, which had been the scene of the Jackson Day Dinner a few nights before, would have paraphrased General Jackson's famous toast—"Our Federal Union; it must be preserved!"—by substituting Council for Union. Indeed, he spoke with such emphasis and conviction on this subject that were the engineers of the country to rally wholeheartedly to the cry they would find themselves possessed of the unity they have long talked about and their leaders would be faced with immediate and perplexing problems of using it wisely.

In the Jacksonian parallel are to be found encouraging and disquieting precedents. National unity was not easily or quickly attained, and its preservation has cost heavily in human effort and sacrifice. So after less than two decades in which to achieve effective and real unity in the engineering profession, the American Engineering Council should not succumb to frustration and discouragement. Certainly, if Council's difficulties are largely financial, real as these may be, they are not likely to ruin a worthy cause completely. Great social movements are not easily comprehended or defined, particularly by the generation in which their stirrings are first felt.

If the need for the unity of the engineering profession exists, as Mr. McClellan so eloquently insisted it does, lack of money to carry on the routine work of one mechanism by which it may be ministered to in an organized and orderly fashion will become a less serious handicap where the will to effect it is strengthened by the unalterable convictions of a majority of persons who make up the profession. A number of organized groups within the profession—the national, state, and local societies that comprise the present A.E.C.—hold this conviction. Through the A.E.C. they propose to arouse and encourage it in others. In addition to the fifty three at present bearing the torch at no little sacrifice to their activities in other areas of engineering interest, probably at least one hundred more should be added—some of which are of great national and numerical importance. How to imbue these organizations outside the A.E.C. fold with enthusiasm for its ideals that can be translated in terms of active support is one of the greatest tasks confronting the Council today.

Many statements in support of American Engineering Council have been written and uttered since its formation a couple of decades ago. Some have described its plans and purposes and others have recorded its achievements. It is surprising, therefore, that so few engineers, individually, have grasped its underlying significance. Undoubtedly, what it means to one group is not what it means to many others. A Washington Embassy to some, cynically construed as a lobby, perhaps, by men of selfish purpose; an employment agency; an overreaching busybody interfering in the vested interests of technical societies; a select circle of self-glorified stuffed shirts; a whipping boy for the profession on whom to shift burdens that are irksome to individuals and organized groups; a research organization for the preparation of reports on engineering subjects; a spokesman for the profession; a conductor of forums; a welfare institution; a guild or trade union; an agency for standardizing salaries and collective bargaining—what fundamental concept of professional unity and idealism can be formulated out of these that can attract and deserve the support of all engineers?

Perhaps the best answer to this disturbing question was given by Vannevar Bush in his address at the All-Engineers' Dinner, previously mentioned. In the March issue the text of this address, released too late for February, will be published. Those who heard the address experienced a sensation of inspiration that lifted them spontaneously into a realm of comprehension and enthusiasm that was very affecting. From a preamble which at first appeared to be a somewhat academic discussion of the philosophy of professionalism and the traditions which engineers inherit from the medicine man in common with the more clearly defined professions of the preacher, the educator, the physician, and the lawyer, Dr. Bush, warming to his subject, launched into a vigorous and fervent appeal for the support of the ideal toward which American Engineering Council has been groping. Realization of that ideal, is a task which all engineers face.

But inspiration and enthusiasm for an ideal are not enough. Just as Dr. Bush's New England twang is characteristic of his speech, so is a native realism characteristic of his ideas, and realism there was in his address. He sensed the hazards and admitted the mistakes as the true engineer must.

Again the Jacksonian parallel is useful. Unity leads to centralization which in itself holds grave dangers for those who attempt its administration. Jackson saddled the country with the spoils system; it must not be forgot that a profession may prostitute its power and authority by becoming a closely organized guild with restrictive

and selfish principles that exact tribute from society. Jackson's administration and that of his successor ran into an economic depression and its place in history is clouded by financial disorders; money always has and always will, as the A.E.C. too well knows, speak with a loud and commanding voice; what can be done in prosperous times goes badly or not at all in times of adversity. Above all, however, speaks the voice of the people; and as that voice brought Jackson into power, and swept his party out of it later, so the voice of the engineer and of the public will affect the destiny of American Engineering Council or whatever agency embodies the professional ideal. The expression of that ideal is, in the words of Dr. Bush, simple ministration to the people.

Aeronautical Research

IN 1933 on Engineers' Day at the Century of Progress Exposition at Chicago, Juan de la Cierva set one of his "flying windmills" down on the field in front of an admiring group of engineers and received from the hands of Edwin E. Aldrin, chairman of the Daniel Guggenheim Medal Board of Award, the Guggenheim Medal "for development of the theory and practice of the autogiro." On Jan. 9, 1939, his name was added to those of da Vinci, Montgolfier, Wright, and Langley on the facade of the Daniel Guggenheim School of Aeronautics at New York University. At the N.Y.U. memorial services to the inventor of the autogiro, who was killed in a plane crash in 1936, Alexander Klemin, member A.S.M.E., director of the school, revealed that a $15,000 de la Cierva Memorial Fellowship for research in rotary-wing airplanes was being established, and Edward J. Noble, chairman of the Civil Aeronautics Authority, pointed out that last year Congress had authorized, but not appropriated, $2,000,000 for the development of aircraft, and announced that the CAA had asked the Secretary of War that the Authority be allotted some $400,000 of that sum when appropriated. "We have very definite plans for the purchase of rotary-wing aircraft of several types," he said. "We propose to fly them and analyze them and study them under the most precise scrutiny." One of those other types of aircraft, the helicopter, was discussed in an able paper by Henrich Focke, eminent German developer of this type, which was presented at the 1938 A.S.M.E. Annual Meeting. Thus does the fertile restlessness of men's minds continue to increase the harvest of their achievements.

Creatures of the peaceable researches of science and engineering, aircraft have developed some of the most important and incalculable problems of warfare and international relations. In crude and experimental forms they were subject to rapid development and severe test during the World War so that their military uses far outstripped civil application. With the end of the War public interest waned temporarily; and it was in those brief years that the engineer's interest in them was kept alive by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS through technical papers sponsored by the Society's Aeronautics Division. As developments progressed and the inevitable usefulness of aircraft, for civil as well as military purposes, again attracted public attention, popular and commercial interest grew rapidly with each new spectacular demonstration of the practicability of flying. Today the world is keenly apprehensive of what scientific research has developed in aeronautics, and the fate of nations, in no small measure, hangs on the supremacy in the air that research largely controls.

All of this lends interest and importance to the twenty-fourth Annual Report of the National Advisory Committee for Aeronautics, recently released, from which the following passages are quoted:

"Once a nation has embarked upon a program intended to develop its air strength to maximum effectiveness, the provision of adequate laboratory research facilities and the training of skilled research personnel become of fundamental importance. The major European powers at the present time are engaged on relatively large aircraft-building programs which are being prosecuted under feverish pressure. Mere numbers of aircraft, however, are not in themselves sufficient for an adequate modern air force. It is of even greater importance that the aircraft be of the most effective design. The advances in aeronautical science are so rapid that assiduous attention to the subject cannot with safety be suspended for even a brief period. Where a few years ago we were pleased with speeds of around 200 miles per hour, we now seek to attain with fully loaded service airplanes speeds of 300 and 400 miles per hour. It is not only good policy from a financial consideration, but also vital from the standpoint of national defense, that American aircraft have a performance equal or superior to that of a potential enemy. This principle necessitates serious consideration of American aeronautical research and experimental facilities.

"During the last four years, however, there has been increasing emphasis on aeronautical research on the part of European powers. They have greatly developed and extended their research facilities. In the rapidly advancing science of aeronautics, research problems increase in number and in difficulty with every material advance in speed, and the importance of prompt solution becomes relatively greater. The Committee's laboratories at Langley Field, Va., are working under high pressure. The requirements of the Army, the Navy, and the Civil Aeronautics Authority for the immediate solution of pressing problems are being met. But they are met at the expense of interfering with or neglecting the more fundamental scientific long-range investigations that in the end mean much to the advancement of American aeronautics. The Committee, therefore, in October, 1938, created a Special Committee on Future Research Facilities. It is expected that its recommendations will be made the subject of a special report to the Congress. In the meantime, the addition to the Committee's research facilities at Langley Field of a structures research laboratory is urgently needed..."

It is not hard to convince engineers of the value of research in almost any form. In aeronautical research, however, the immediate stakes are so high that the fate of civilization itself seems to depend upon it, and public recognition of its importance should be stimulated.

Considerations on RUPTURE *Under* TRIAXIAL STRESS

By P. W. BRIDGMAN

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INTRODUCTION

IN ROUTINE testing of engineering materials the stresses which are most frequently employed are simple tensions or compressions. It is easy both to apply such stresses in the testing laboratory, and to calculate the resulting strains and distortions, so that it is simple to interpret the results. It is recognized, however, that materials in practical use are often subject to more complicated sorts of stress, and accordingly there have been many efforts to make the stresses employed in testing cover a wider range of type than simple tensions and compression. Perhaps the simplest of these is testing under shearing stress by torsion; the principal stresses are here two-dimensional rather than one-dimensional, that is, a tension and an equal compression at right angles to it. However, such a method of testing suffers from the disadvantage that the distribution of stress is by no means uniform, the stress being a maximum at the outside of the rod and zero on its axis in the ordinary method of testing by twisting a circular cylinder.

It is generally recognized that methods of testing would be desirable in which the two principal stresses are each uniformly distributed throughout the material, and each independently controllable. It is not very easy to apply such an independently controllable pair of uniform principal stresses however, and in practice few experiments of this kind have been made. The special case of this sort of thing that is probably easiest to realize is when the two principal stresses are each compressive and numerically equal. This can be realized by exposing a cylindrical rod to fluid pressure on the curved surface, the ends of the rod projecting out of the pressure vessel through stuffing boxes.

But even such a simple stress distribution as the negative of this, that is a hydrostatic tension on the curved surface, would be difficult to realize. When we come to the full generality of the next step, three uniformly distributed principal stresses, each independently controllable, the conditions are so difficult to realize experimentally that there have been practically no attempts. The simplest special case here is obviously when the three stresses are equal and compressive, that is, a hydrostatic pressure. This can be easily realized, but from the point of view of actual testing it is of minor interest, because rupture never occurs under hydrostatic pressure. The negative of this, hydrostatic tension, has not yet been realized, at least not up to magnitudes of stress sufficient to produce rupture, and the difficulty of realizing it is at present doubtless great.

The fact that there has been so little discussion of rupture in the three-dimensional case is without doubt to be explained by the fact that the conditions have not been realized experimentally. However, in spite of the difficulty of attaining in experiment the full three-dimensional variability of stress, the author believes that nevertheless by considering what sorts of phenomena might be anticipated in the full three-dimensional range we will obtain suggestive points of view with respect to some of the two-dimensional phenomena which are under control.

GENERAL CONSIDERATIONS

In this paper the author proposes to make such an analysis from the full three-dimensional standpoint. One reason that such an analysis is profitable is that it is sometimes possible to analyze a two-dimensional distribution of stress into a hydrostatic pressure or tension with a superposed one-dimensional stress. The introduction of a hydrostatic-stress component into the total stress is important because a wide experience has shown that although hydrostatic pressure modifies the properties and behavior of substances, the qualitative behavior remains recognizable without great modification. A body which is a conductor of electricity under normal conditions continues to be a conductor when subjected to pressure, and the change in conductivity may be described with the help of a "pressure coefficient." If a fluid offers viscous resistance to flow under normal conditions it continues to offer viscous resistance when exposed to hydrostatic pressure, and the alteration in its behavior may be described with the help of a pressure coefficient of viscosity. If a metal wire breaks in tension when a sufficiently great weight is hung on it, then it may still be made to break by hanging a sufficiently great weight on it when the wire and the weight are together immersed in a fluid medium carrying hydrostatic pressure. The change in weight required to break the wire is to be described in terms of a pressure coefficient of tensile strength. Rupture, as well as any other physical behavior, is modified by the application of pressure, but not so as to become qualitatively unrecognizable, at least if the pressure does not vary too much, and the magnitude of the alteration of stress which produces rupture can be described in terms of a pressure coefficient. If any justification is felt to be necessary for this statement, it can be found in examples which the author has frequently observed during the course of his high-pressure experimenting of objects ruptured while exposed to a fluid medium carrying hydrostatic pressure.

All this not only agrees with experiment, but also seems right from the theoretical point of view, because the hydrostatic pressures which can be ordinarily applied are not large enough to greatly modify the atomic forces—the compressibility and the other elastic constants are not greatly modified, so that we are still approximately in the range of Hooke's law.

Let us now set ourselves the problem of discussing the behavior of a unit cube of some definite substance. To the opposite pairs of faces of this cube may be uniformly applied arbitrarily and independently variable normal forces, the forces of course being equal in pairs as demanded by mechanical equilibrium of the whole cube. That is, we suppose any required system of principal stress components applicable to the cube. Any particular stress system can be plotted as a point in a three-dimensional diagram, with three orthogonal Cartesian axes corresponding to each of the three axes of the cube. When

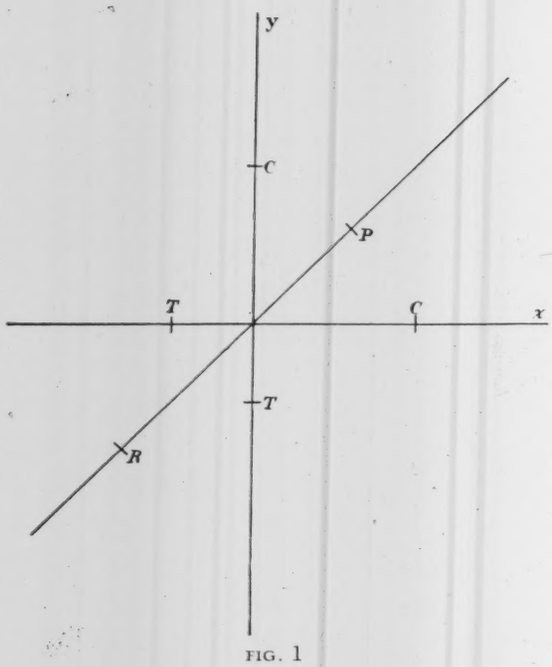

FIG. 1

the stress reaches certain values the cube will fail by rupture. The stress points in the three-dimensional plot corresponding to rupture will lie on a surface, the rupture surface, which we now discuss further. For the present, suppose we are dealing with a brittle substance which breaks suddenly when it breaks; otherwise rupture is not always clean-cut and the rupture surface would not be well-defined. If instead of rupture there is some other phenomenon which has a cleanly marked onset when stress passes some critical value, we could construct a corresponding surface for it. Such might be the beginning of permanent set, or the failure of the proportional limit, if only these phenomena could be sharply distinguished. We can in any event approximate to such surfaces by setting numerical limits.

We suppose that the substance is homogeneous and isotropic, so that its rupture surface is symmetrical with respect to the three axes. It will be convenient to map out the rupture surface by first marking its intersections with the coordinate axes, and then finding the curves which trace its intersection with various important planes. Take as typical the x-y plane, and take compressive stress as positive. Then the intersections with the positive x- and y-axes denote the rupture point, or the strength of the cube under simple compressive stress. Similarly, the intersections with the negative axes mark the strength in simple tension. If the substance is like ordinary glass the strength in tension is markedly less than that in compression, as indicated in Fig. 1.

RUPTURE UNDER COMBINATIONS OF COMPRESSIVE STRESS

Now allow the stress system to have two components, and for the present make these two components equal, so that the point in the stress diagram lies somewhere on the 45 deg line running from southwest to northeast. For some value of the two component compressive stress the cube will rupture; denote the corresponding stress by the point P. We might call this type of rupture the C_2 type—two equal components of compressive stress. The simplest way of realizing this type of rupture, as already suggested, is to subject a cylindrical rod to hydrostatic pressure on its curved surface only, leaving the ends free through stuffing boxes. The author has referred to this kind of rupture in other places as the "pinching-off" effect (1).[1] One can approximate to it in a plastic substance like putty by squeezing a roll of putty out endwise from one's clenched fist. The "pinching-off" effect may be readily produced in brittle materials like glass in the very simple apparatus shown in Fig. 2. The requisite pressure on the piston may be produced by a 5-ton arbor press. Study of the fractures produced in an apparatus of this kind will be found most instructive.

What would one who had not experienced it expect this C_2 type of fracture to look like? Probably like some sort of elaboration or modification of the simple compressive fracture, which in the case of glass frequently means crumbling or powdering of the specimen. But as a matter of fact the fracture is like a typical tensile fracture under a tension acting along the third axis, that is, the axis along which by construction there is no component of stress. This means that for a brittle material like glass there is a clean rupture on a plane perpendicular to the axis of zero stress, or if the material is ductile like mild steel, the rod necks down and breaks with a conical pit exactly like an ordinary tensile break. The phenomenon of a rupture with all the characteristics which we are accustomed to associate with a break under tension occurring in a direction in which the component of stress vanishes is so paradoxical to many people that they are unwilling to accept it, but must argue that in some way a component of tension in the direction of fracture has been smuggled in and is responsible.

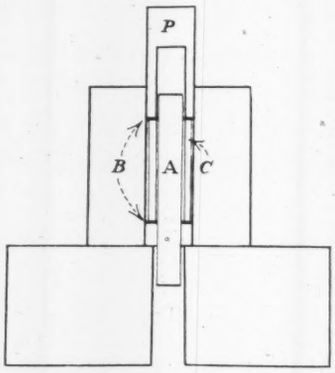

FIG. 2 APPARATUS FOR PRODUCING THE "PINCHING OFF" EFFECT

(The diameter of the rod is $^5/_{16}$ in.; A is the solid glass rod to be ruptured; B are tightly fitting red-fiber washers; C is a rubber tube loose inside and out, copiously smeared with molassas, to produce approximately hydrostatic pressure and reduce friction; and P is a hardened-steel piston forced in by an arbor press.)

The point which the author wishes to make is that the phenomenon becomes understandable and to be expected from the point of view of the complete three-dimensional figure. Consider the section of the surface standing perpendicular to the plane of the paper of Fig. 1 on the 45-deg line. This plane, shown in Fig. 3, will contain the axis of hydrostatic pressure and tension, that is, the line equally inclined to the three axes, so that a point on the line denotes a stress with three equal components. Since rupture does not occur under pure hydrostatic pressure, at least for any ordinary pressure not great enough to break the atoms themselves, the rupture surface will be open in the direction of the axis of hydrostatic pressure, and will stretch toward infinity without ever intersecting it. Fig. 3 shows at once that the stress at the point P, where the C_2 type of fracture occurs, is the sum of the hydrostatic pressure represented by the point A and the simple tension along the z-axis represented by the length AP. That is, the two-dimensional

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

compression C_2 may be described as a hydrostatic pressure of intensity equal to the intensity of the components of C_2, plus a tension, also numerically equal to the components of C_2. Expressed analytically, the stress system $(X,X,0)$ is equivalent to the hydrostatic pressure (X,X,X) plus the tension $(0,0-X)$. Since the stress at P by construction and hypothesis produces rupture, we are to expect, by our principle that hydrostatic stress does not essentially modify qualitative behavior, that the character of the rupture will not be essentially different from ordinary tensile rupture produced by a one-component tension. Although the character of the fracture does not change, the magnitude of the superposed component of tensile stress required to produce it will be somewhat modified because of its pressure coefficient. General experience, which is consistent with the theoretical expectation that when a substance is compressed the atomic forces become somewhat greater, suggests that the pressure coefficient of tensile strength is positive. In accordance with this, as shown in Fig. 3, AP has been drawn somewhat longer than OT, so that the trace of the rupture surface TP diverges from the hydrostatic-pressure axis in the direction of increasing pressure. This is also consistent with our previous observation that the rupture surface must be open in the direction of the hydrostatic-pressure axis.

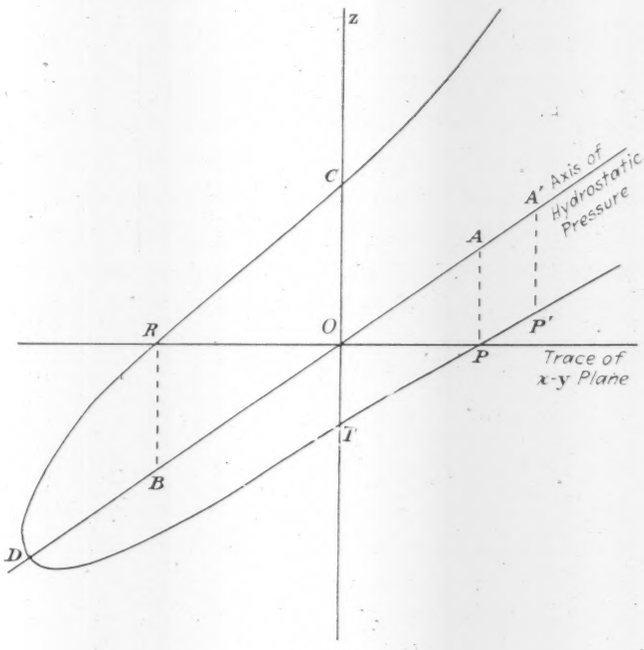

FIG. 3

What is the character of the rupture surface in the immediate neighborhood of P? There seems no physical reason for any discontinuity here, so that we may expect the trace of the surface to be roughly linear through T and P, as shown in Fig. 3. This means that at points beyond P, at P', for example, all three components of stress are compressive and correspondingly, if the point A is sufficiently beyond P, all three components of strain may be shortenings. But the stress can be described as the hydrostatic pressure A' plus the superposed tension $A'P'$; therefore, we are to expect that the rupture will still be tensile in character. This at first sight appears perhaps even more paradoxical than the "pinching-off" effect, namely a tensile break with every stress compressive and every strain a shortening. The author has found that many people aggressively refuse to accept it. This sort of fracture has, however, been well substantiated by experiment. The author has realized it under simple conditions (1, 2), and there are the elaborate experiments at Illinois (3) of rupture of cylinders of concrete exposed to lateral hydrostatic pressure and longitudinal compression on the parts projecting through stuffing boxes. The photographs of the Illinois specimens show strikingly the tensile character of the fracture when the longitudinal compressive stress vanishes or is less than the lateral pressure, but apparently no great significance was attached to the character of the fracture by the experimenters.

The same sort of analysis that we have just applied to the trace of the fracture surface with the 45-deg plane through P may also be applied to the trace through C, shown in Fig. 3. Fracture on this trace may be described as fracture in simple one-dimensional compression with superposed hydrostatic pressure. The character of the fracture on this trace will therefore be that of a simple compressive fracture. The strength in compression may be expected to increase with hydrostatic pressure; for this there is dramatic experimental justification in recent experiments of Griggs (4). This means that the sheet through C will also diverge from the axis of hydrostatic pressure, as is indicated in Fig. 3. The experiments of Griggs indicate that departures from linearity on this sheet will soon come into evidence. The experiments at Illinois in which the longitudinal compressive stress was greater than the lateral pressure are also of this type.

RUPTURE UNDER COMBINATIONS OF TENSILE STRESS

Consider next the prolongation toward the negative side of the trace through C. Let us for simplicity suppose that the intersection of this sheet with the 45-deg plane continues straight, and denote its intersection with the x-y plane by R. The point R therefore indicates fracture under a system of two equal tensions, with zero principal stress along the third axis, that is, the z-axis in Fig. 3. We may denote this type of fracture by T_2 to suggest two equal tensions. What is the character of the T_2 rupture at the point R? Perhaps one's first impulse would be to say that it must be like an ordinary rupture in tension, only "more so." What "more so" means specifically is a little difficult to see—perhaps two systems of tension cracks at right angles. But now the three-dimensional representation makes a plausible suggestion. The stress at the point R is the sum of the hydrostatic tension represented by the point B and the compressive stress given by the length RB, which is also numerically equal to the hydrostatic tension at B. If our principle is correct that hydrostatic tension does not qualitatively alter the phenomenon, we expect the character of the fracture to be like that of a compressive fracture rather than of a break in tension. The numerical magnitude of the crushing strength at R is obtained from that at C by applying a correction determined by multiplying the pressure coefficient of compressive strength by the pressure (negative) at B. For a substance like glass, for which we may expect a comparatively small pressure coefficient and for which the strength in compression is notably greater than that in tension, the distance RB will be greater than the distance OT but less than OC; it is so shown in Fig. 3.

In order to have a name by which we may talk about it, we may call this T_2 type of rupture the "rending" effect. It does not appear how one would realize this type of fracture with ordinary materials. A two-dimensional distribution of tension can be produced at the junction of the arms of a cross by applying tension to the arms, but if our expectation is right, rupture will occur by ordinary tension in the arms before sufficient stress can be built up at the junction to produce fracture there by the "rending" effect. If, however, the ordinary compressive strength be notably less than the tensile strength, one could hope to realize it in such a cross. In very weak materials one could realize it by cementing to the faces of the test cube tension members, provided the tensile strength of the ce-

ment is sufficiently greater than the rending strength of the material.

What now happens to the rupture surface at hydrostatic tensions much greater than that at *B*? The author believes it is universally accepted that the rupture surface is closed in this direction, and that any substance could be ruptured by the application of a sufficiently great hydrostatic tension. A sufficient argument for this is that all substances are capable of assuming the vapor form, that vaporization requires energy, and that an indefinite amount of energy can be put into a substance by stretching it indefinitely in three dimensions. At the same time it is admittedly most difficult to realize such conditions in the laboratory, and the character of the corresponding rupture is for the present conjectural. Just to have a name to call it by we may call it the T_3 type of rupture. Rupture of this type will be said to be the "disruptive" effect, and the corresponding point where the rupture surface cuts the axis of hydrostatic tension will be denoted by *D*. As in the two-dimensional case, this may perhaps be realized in sufficiently weak materials by cementing tension members to the faces of the test cube. The author probably approximated to it on one occasion with glass. A solid sphere of glass was exposed to high hydrostatic pressure, when the pressure vessel accidentally ruptured with unusual violence. The glass was found reduced to an impalpable powder, supposedly by the inertia effect attending the sudden release which subjected the glass momentarily to a hydrostatic tension approximately equal to the previous hydrostatic pressure. This suggests the character of the fracture that may be expected. The author has not been able to repeat the experiment, however, in spite of several attempts.

Fig. 3 shows that it is geometrically possible to pass on the rupture surface from the point *C*, through *R* and *D*, to *T*. This suggests the possibility of a continuous change in the type of rupture from compressive rupture at *C* to tensile rupture at *T*. The author's conclusion that the "rending" type of rupture at *R* is predominantly compressive in character is therefore probably not as secure as the conclusion that the "pinching-off" type of rupture at *P* is predominantly tensile. However, the inference has a good degree of plausibility for ordinary substances in which there is no appreciable departure from Hooke's law up to the rupture point. It is to be considered that probably a high three-dimensional tension is necessary to rupture, so that the actual rupture surface may be much more extended in the direction of *D* than shown in Fig. 3. This allows chance for marked variation in the character of rupture between *R* and *D;* the possibility must also be considered that the curve may have breaks between *R* and *D*, and not be smooth as drawn.

At points on the rupture surface sufficiently below *R* we may have a highly paradoxical state of affairs analogous to that already found in the neighborhood of *P*, namely, rupture which is predominantly compressive in character with a stress system whose three principal components are all tensions and a strain system whose three principal components are all extensions.

THE COMPLETE RUPTURE SURFACE FOR MIXED STRESSES

Having now mapped out the section of the rupture surface which includes the axis of hydrostatic stress let us return to complete the discussion of the intersection with the *x-y* plane. We already have the points *C*, *C*, *T*, *T*, *P*, and *R* as shown in Fig. 1. We begin by inquiring what is the probable character of the intersection in the neighborhood of the point *C* on the *x*-axis. At *C* we have compressive rupture under a one-dimensional stress *C* along the *x*-axis. This compressive rupture may take various forms for different substances; in addition to the crushing and powdering already mentioned, we may have "slabbing off" in the faces perpendicular to the *y*- and the *z*-axes, or the expulsion of shear wedges from these faces. Suppose we now apply a small compressive stress along the *y*-axis; then, the elongation parallel to the *z*-axis is increased, while that parallel to the *y*-axis decreases. Slabbing off and wedging out from the *z*-face is facilitated, while that from the *y* face ceases. The rupture changes from taking place indiscriminately on the *y*- or *z*-face to taking place exclusively on the *z*-face. Furthermore, the main compressive stress *C* along the *x*-axis can now be reduced somewhat and still produce rupture, since it is assisted by the compression along the *y*-axis. That is, the initial slope of the intersection at *C* is into the second quadrant, as shown in Fig. 4. This is consistent with the observation we have already made that the stress at the point *P* in a substance like glass is notably less than the stress *C*. Since the rupture surface is symmetrical about the 45-deg line, the curve may be plausibly completed in the first quadrant as shown. Between the points *C* and *P* we have a change in the character of fracture from compressive to tensile. It is not to be expected that necessarily, or even probably for all substances, the rupture surface is smooth between *C* and *P* as drawn, or that continuous transition occurs between the crushing and tensile types of rupture. However, such continuous transition is conceivable and doubtless occurs in materials like glass; as one passes from *C* to *P*, failure by slabbing off becomes more and more dominant, and failure by the expulsion of shearing wedges disappears. In fact, from this point of view, failure by slabbing off in compression, which is not so very common, is merely the premonition of the tensile failure into which the compressive failure is transformed.

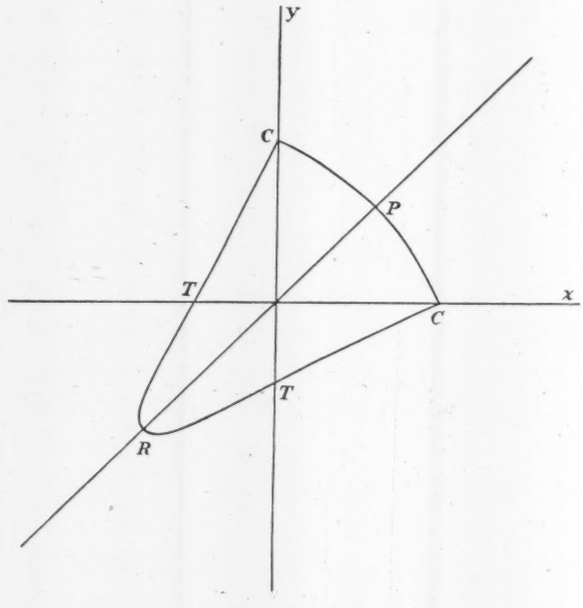

FIG. 4

Consider now the effect of adding a small component of tension along the *y*-axis instead of the compression that we have just considered. There will now be an additional extension along the *y*-axis while the extension along the *z*-axis will be diminished. Failure will now take place by slabbing off or the expulsion of shear wedges in the *y*-face. Again the main compression along the *x*-axis necessary to produce rupture becomes somewhat less because of the assistance it receives from the other component, and the curve starts off below *C* in the direction of the third quadrant, as indicated. There is, then, a cusp in the rupture surface at *C*, corresponding to the discontinuous change in the fracture from a *z*-face to a *y*-face fracture.

In the fourth quadrant, the curve must eventually land on the point T. Again, whether it is continuous in this quadrant doubtless depends on the type of substance. Continuity means continuous passage from compressive to tensile rupture; if the surface is continuous from C to P it is probably continuous from C to T. It is so drawn in Fig. 4, which may perhaps be expected to apply to substances like glass. If, however, the substance readily flows by shear, as in the case of many ductile materials, then at some point in the fourth quadrant, where the shearing stress reaches a critical value, we may expect another discontinuity in the curve.

The curve in the second quadrant is symmetrical with that in the fourth.

Next, how does the curve enter the third quadrant from the points T? At T rupture is a tensile break on planes perpendicular to the axis of tension. Additional small compression at right angles increases the extension along the main tension axis, and makes rupture by the main tension easier. On the other hand, an additional small tension along the perpendicular axis decreases the extension along the axis of main tension and makes rupture by the main tension more difficult. That is, there is no discontinuity in the character of rupture on going through T, and the rupture surface passes smoothly through this point without a cusp. At R the character of the rupture is compressive. If continuous transition is possible from tensile to compressive rupture, as we are supposing, then we may fill in the curve continuously between T and R, as shown in Fig. 3. If, on the other hand, the substance is such that continuous transition in the type of rupture is not possible, and in particular if there is a discontinuous change from a tensile to a shearing type, then we may expect discontinuities between T and R, similar to the discontinuities in the other quadrants, whose possibility we have recognized, but have not attempted to represent specifically in the diagrams.

We now have, in virtue of symmetry, six sections of the complete three-dimensional rupture surface, namely three sections made by the three coordinate planes, and three by the three 45-deg planes through the axis of hydrostatic stress. By filling in smoothly over these six sections it should be possible to get a fairly adequate idea of the complete rupture surface, even if there are still other discontinuities in the surface beside those whose possibility or probability has been indicated. For the scattering of actual experimental points in rupture experiments is usually so great that there is seldom adequate justification for drawing curves or surfaces with discontinuities.

When "filling in" the surface it is to be kept in mind that it is only on the three 45-deg planes that the total stress can be analyzed into a hydrostatic stress plus a one component simple stress, so that it is only on these planes that our argument as to the character of rupture applies. On intermediate parts of the surface one may be prepared for considerable variations from material to material. It is to be remarked that if the material is one for which failure in shearing is important, it is possible to determine a "pressure coefficient of shearing strength" from the geometrical surface by a method entirely analogous to that used for "the pressure coefficient of tensile strength," and similar arguments may be expected to apply to it.

CONNECTION WITH CONDITIONS OF RUPTURE IN GENERAL

Finally, what is the connection between what we have been doing and the "conditions of rupture" or the "theory of rupture?" It is to be emphasized that up to now we have been concerned with the rupture surface which reproduces the experimental results on a particular material, in a particular shape, and with a particular manner of distribution of the surface forces.

Common practice in dealing with rupture would suggest that we use this surface in the attempt to determine when rupture occurs under the most general conditions in the particular material by setting up the thesis that rupture always occurs in this particular material whenever the local stresses at any point of it reach values corresponding to any point on the rupture surface. It is, however, certain that there are cases in which rupture is determined not only by the stress conditions but also by conditions such as the nature of the surface of the specimen, and also probably by such other conditions as the way in which the distribution of stress departs from homogeneity. There is also the enormously important factor of repetition of stress application. Further, under some circumstances the general geometrical configuration seems to play an enormously important rôle; thus, the author has found that heavy-walled glass cylinders will support external pressures of 30,000 atm, which means a stress difference of 60,000 atm at the internal surface, far above the crushing strength under more normal conditions. The decisive rôle of surface conditions is established by the well-known experiments of Griffiths (5) on glass or of Orowan (6) on mica. A complete formulation of the conditions of rupture, even for a single material, depends on many more variables than merely the stress components, and is a much too complicated thing to reproduce by any such simple surface as we have been considering. At the best such a surface can be expected to be of value in determining rupture only for particular kinds of materials, or for particular ranges of stress. The metals of ordinary engineering practice do seem to be materials for which the surface conditions are relatively unimportant, so that we may expect the experimental mapping out of a surface such as we have considered to be important in indicating when to expect rupture under practical conditions, especially in those cases where the stress distribution is approximately homogeneous. However, the general application to metals is obscured by the fact that failure in metals is often not a clean-cut phenomenon. For substances like glass we should expect the applicability of such a surface to be obscured by the capriciousness of the results, because surface effects are known to be very important.

CONCLUSION

The complexity of the whole subject is obviously enormous and baffling. The simplifying idea which this paper would chiefly emphasize is that a pure hydrostatic pressure or tension does not produce large qualitative changes, and that it is therefore of value to resolve, when possible, a stress system into a hydrostatic stress plus a superposed simple stress, and that the physical effects are qualitatively those of the superposed simple stress.

BIBLIOGRAPHY

1 "Breaking Tests Under Hydrostatic Pressure and Conditions of Rupture," by P. W. Bridgman, *Philosophical Magazine*, vol. 24, July, 1912, p. 66. Also: "Some Mechanical Properties of Matter Under High Pressure," by P. W. Bridgman, Procceedings of the Second International Congress for Applied Mechanics, Zurich, Switzerland, 1926, p. 59.

2 "Theoretically Interesting Aspects of High-Pressure Phenomena," by P. W. Bridgman, *Review of Modern Physics*, vol. 7, 1935, p. 31.

3 "A Study of the Failure of Concrete Under Combined Compressive Stresses," by F. E. Richart, A. Brandtzaeg, and R. L. Brown, Engineering Experiment Station, University of Illinois, Urbana, Ill., Bulletin No. 185, November, 1928.

4 "Deformation of Rocks Under High Confining Pressures," by D. T. Griggs, *Journal of Geology*, vol. 44, 1936, p. 541.

5 "The Phenomena of Rupture and Flow in Solids," by A. A. Griffith, Philosophical Transactions of the Royal Society of London, vol. 221, 1920, p. 163.

6 "Die Zugfestigkeit von Glimmer und das Problem der technischer Festigkeit," by E. Orowan, *Zeitschrift für Physik*, vol. 82, 1933, p. 235.

The POSSIBLE USE *of* HELIUM *in* SUBAQUEOUS ENGINEERING[1]

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PRIOR TO 1918, helium was mainly of abstract scientific interest. During the War, however, George A. Burrell, of the U. S. Bureau of Mines, then Colonel in charge of Chemical Warfare Investigations, suggested the use of this non-inflammable gas in balloons. A very eminent physicist promptly countered this suggestion with the statement that as the weight of helium is to that of hydrogen as 4 is to 2, it would have only half the lifting power. But he admitted this as the one error of his life when Burrell pointed out that as the corresponding weight of air is 28, the lifting power of hydrogen is $28 - 2 = 26$, and that of helium $28 - 4 = 24$.

Recently Dr. Alvan Barach, at the Presbyterian Hospital, New York, N. Y., has introduced a mixture of 79 per cent of helium and 21 per cent oxygen for the relief of acute asthma. In that disease the narrowing of the airways of the lungs renders breathing difficult; and the more ready diffusibility of helium, as compared with the nitrogen of the air, markedly decreases the work of breathing. Anesthetists are now actively interested in the advantages of helium as a diluent for oxygen particularly at the close of anesthesia. Experience has shown that if any of the airways become occluded with mucus while the lungs are filled with such readily absorbable gases as oxygen and the anesthetics, those parts or even an entire lung may be collapsed by the absorption of its gaseous contents. To counteract this condition of atelectasis, and to reexpand the lungs, promotion of deep breathing and inhalation of a mixture of 79 per cent helium and 21 per cent oxygen are the most effective means.

These uses of helium have demonstrated a point of primary importance; namely, that helium is an entirely harmless and nontoxic gas. It is also considerably less soluble in the fluids and particularly in the fatty substances of the body than is nitrogen. At very high pressures nitrogen is slightly anesthetic; helium is not. These advantages of helium are now being utilized for deep-sea diving, particularly in the United States Navy in the lifting of accidentally sunken submarines and the rescue of their crews.

TABLE SHOWING RELATIVE SOLUBILITIES AND DISTRIBUTION RATIOS OF NITROGEN AND HELIUM IN WATER AND OIL

Helium/nitrogen in water	2 to 3
Helium/nitrogen in oil	1 to 4.5
Helium in oil/helium in water	1.7 to 1
Nitrogen in oil/nitrogen in water	5.24 to 1

Quoted from A. R. Behnke and O. D. Yarbrough, *U. S. Naval Med. Bull.*, vol. 36, Oct., 1938, p. 542.

The investigations in the Navy on this use of helium were begun ten years ago. According to a statement of the Navy Department released for publication in the daily papers of August 8, 1938, a depth of 400 ft has recently been attained in open sea tests, and pressures equivalent to 500 ft have been tolerated under experimental conditions by men wearing a newly devised diver's suit designed to supply the wearer with a mixture of helium and oxygen. Previously, the greatest depth attained by divers wearing the standard diving suits and breathing compressed air, was 306 ft during salvage operations for the submarine sunk off Honolulu February 25, 1915. Under the high pressure at which air must be supplied in order to keep the rubber suit expanded and enable the diver to breathe, a correspondingly large amount of nitrogen becomes dissolved in the blood and tissues. This does no harm so long as the body is under pressure. But if the diver is brought to the surface and thereby decompressed too rapidly for the nitrogen to diffuse out through the lungs, bubbles form in the blood and tissues. Pain, injury and even death may result. In order to prevent this development of compressed air illness, or "bends," the work periods had to be brief and the periods of decompression many times longer.

With these successful uses of helium as a background the question presents itself whether this gas has not some important possible uses in work in caissons and in subaqueous tunneling. At first sight it would appear that to fill the caisson or tunnel with a mixture of helium and oxygen would involve a prohibitive expense. Even to use this mixture in the air locks during decompression would probably cost more than would be justifiable; for after the first supply of the mixture there would have to be a continuous stream of oxygen together with provision for absorbing the carbon dioxide and heat given off by men sitting close together in a small chamber.

There is, however, one important and only moderately expensive use for the helium-oxygen mixture. In spite of the care now commonly exercised and the time required by law in the decompression of men working in caissons and subaqueous tunnels, cases of illness are still sufficiently common to require the rather frequent use of the so-called "medical lock." At the first sign of trouble the man is placed in this chamber and recompressed, after which the pressure is allowed to fall very slowly. While the acute symptoms due to the formation of bubbles are relieved by this treatment, it does not diminish the amount of nitrogen in the body. On the contrary, it tends at first to increase the amount, and thereby to lengthen the time before the man can be safely restored to the outside air. It is probable, however, that this disadvantage may be overcome, the elimination of nitrogen accelerated, and the time in the medical lock decreased safely by the inhalation of a mixture of 80 per cent helium and 20 per cent oxygen. It should be administered by means of the H.H. inhalator now used for the treatment of carbon monoxide asphyxia with 7 per cent carbon dioxide and 93 per cent oxygen.

But it should be emphasized that this inhalation of helium and oxygen should be used with recompression in the medical lock, not substituted for recompression without use of the lock.

[1] Recent comment in the press on the replacement of nitrogen with helium in certain atmospheres led to an inquiry addressed to Dr. Henderson which resulted in the explanation of the reason why one inert gas can beneficially replace another in an atmosphere breathed by deep-sea divers and pneumatic caisson workers. Here is another example of the type cited by Dr. Haggard in the Thurston Lecture published last month of physiology for engineers.—EDITOR.

UNCONSCIOUS TUITION

By HARVEY N. DAVIS

PRESIDENT, 1937–1938, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE TEXT that I have chosen for this sermon is a little pamphlet published over sixty years ago that came only recently to my attention. It was written by the then Bishop of Central New York, the Right Reverend F. D. Huntington, and it was, I am told, well known to many thousands of school teachers in this country, and a part of the required reading in many teacher-training courses. The name of it is "Unconscious Tuition." It is written in the best of the highly embellished style of the period, and is full of quotable epigrams, such as: "The ultimate or total object of the teacher's profession is not the communication of knowledge; . . . education does not consist in inserting facts in the pupil's memory, like specimens in a cabinet, or freight stowed in the hold of a ship. . . . (Nor does education) consist in provoking bare intellectual dexterity, any more than in presenting ascertained truth to the intellectual perceptions; or in both together. Education involves appeals to faith, to feeling, to volition. . . . The true training of the mind involves an engagement of the affections, including taste or the sense of beauty, and love or the sense of good, both the mind's freedom and its harmony being dependent on a healthy heart. . . . In a word, education is not the training of the mind but the training of the man."

Two pages are devoted to classic descriptions of two contrasting schoolrooms; one where "everything seems to be done with an ease which gives an impression of spontaneous and natural energy," and where "attention comes, not as if it were extorted by fear, or even paid by conscience as a duty, but cordially;" the other where the teacher is "the incarnation of painful and laborious striving; . . . a conscious perturbation; a principled paroxysm; an embodied flutter; an honest human hurly-burly;" where the teacher "tries so hard that by one of the common perversions of human nature his pupils appear to have made up their minds to see to it that he shall try harder yet, and not succeed after all."

Elsewhere the Bishop tells the teacher who finds himself confronting an unwonted restlessness in his classroom, "Half your purpose is defeated if the scholars even find out that you are worried. The angel of peace must descend so softly that his coming shall not be known, save as the benediction of his presence spreads order, like a smile of light, through the place."

But best of all perhaps is the succinct remark, "You have to judge an orator as much by what he leaves out as by what he puts in." Therefore, again quoting the Bishop, "Let us proceed, on the ground of this principle, with our proper theme."

The essence of that theme is stated in the opening sentences of the essay as follows: "By unconscious tuition I mean that part of a teacher's work which he does when he seems not to be doing anything at his work at all. It has appeared to me that some of the most nutritive and effective functions of an instructor are really performed while he seems least to be instructing. To apprehend these fugitive and subtle forces, playing through the business of education with such fine energy, and if possible to bring them within the range of a practical dealing and discipline, is the scope of my present design."

His development of this theme is indicated a couple of pages later by that table of contents with which every good sermon begins. He writes: "My main propositions are these three: 1st. That there is an educating power issuing from the teacher, not by voice or by immediate design, as indispensable to his true function as any element in it. 2nd. That this unconscious tuition is yet no product of caprice, or of accident, but takes its quality from the undermost substance of the teacher's character. And 3rd. That, as it is an emanation flowing from the very spirit of his own life, so it is also an influence acting insensibly to form the life of the scholar."

Here we have an answer over sixty years old to the fundamental problem still facing the educators of today. Over and over again are we of the colleges being told by those in industry who hire our graduates that what a young man knows is of far less importance to them than what he is, that our courses in calculus, in thermodynamics, in theory of structures, or in time and motion study are all very well in their way, but that until we can add to our curricula some effective courses of instruction in character-building, we are not properly doing our job. Every college teacher has faced and pondered over this problem ever since he met his first class, and it has been uppermost in the mind of every college administrator ever since he first took his oath of office. And every one of us has come, I believe, to exactly the same conclusion, which is none other than the conclusion reached long ago by Bishop Huntington, namely, that the best way to develop character in a group of young men is to have plenty of it available in the personalities of the teaching staff for the students to see and admire. Then and then only will it pass by "unconscious tuition" into the personalities of the students.

This fundamental fact of pedagogy Bishop Huntington states over and over again, in dozens of felicitous phrases, in his essay. Thus: "My purpose here is simply to show that some of the deepest and most powerful impressions are made on our minds, independently of any spoken or written words, by influences, by signs, by associations, beyond any speech. . . . You know the remark they used to make about Lord Chatham: that everybody felt there was something finer in the man than anything he ever said. We are taught, and we teach, by something about us that never goes into language at all. I believe that often this is the very highest kind of teaching, most charged with moral power, most apt to go down among the secret springs of conduct, most effectual for vital issues, for the very reason that it is spiritual in its character, noiseless in its pretensions, and constant in its operation." And again: "We can easily conceive of all the bare *material* of instruction being conveyed into a schoolroom through a mechanism of pipes in the wall"—now-a-days we would call them radio antennae—"or maps let down by pulleys, and its discipline administered by a veiled executioner, no heart-relations being suffered to grow up between teacher and taught. Into what sort of a bleak degradation would a generation be reduced by such a machinery!" And yet again: "The world is full of proofs of the power of personal attributes. In most situations—in none more than in a school—what a man *is* tells for vastly more than what he *says*. Nay, he may say nothing and there shall be an indescribable inspiration in his simple presence."

In these ringing words we have one of the best definitions I have ever found of that which every college teacher aspires to

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Being that phase of "An Engineer's Philosophy" which constituted the Presidential Address delivered at the Annual Meeting, New York, N. Y., Dec. 5–9, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

be, and every college administrator longs to find, a great teacher. He is a man whose personality is so attractive, and whose character is so fine, that by unconscious tuition he wins the admiration and life-long devotion of his students and all unconsciously influences their ideals and molds their characters, so that they are forever after better men for having sat under him. What one learns from such a great teacher is often a by-product of minor importance, rather than the main object or chief advantage of taking his instruction. Would that every American college faculty might be composed wholly of such men!

Let no one think, however, that it is of no significance what or how such men teach. I venture to assert that it is inherently impossible for a man to teach trivial material, or to teach worthy material badly, and still be such a man, and this for an indirect rather than an obvious reason. It is that the unconscious tuition we are speaking of grows out of the fundamental character of the teacher, and that he who teaches trivially or carelessly, or fails to keep up with the latest progress in his field, to bring to his students the best material available, and to present it in the best way, thereby proves himself to be deficient in that honesty and sincerity of purpose and performance that are the foundations of character. If a man permits his conscious tuition to be poor, his unconscious tuition will necessarily be poorer still.

One other word of warning is delightfully phrased by Bishop Huntington. He remarks: "No moral influence that is put forth, as by deliberate contrivance to put it forth, avails much. It seems as if to go about in cool blood to undertake an influence . . . forfeited the privilege, like getting up sympathy by a conspiracy, or falling in love by a prospectus. Who ever heard of a man becoming influential by saying: 'Go to, now, I propose to be influential?' Something about this great sympathetic force requires that it should be, in a sense, indirect and unconscious, in order that it be valid. There is a providential necessity that it be got by preliminary accretions of merit, and be distributed because it cannot be helped. . . . Matters of mere technical information may be legitimately conveyed by almost any tongue but to exercise the power of character, a character must have been earned. . . . (There is) a fixed connection between a teacher's unconscious tuition and the foregoing discipline of his life. What he is to impart, at least by this delicate and secret medium, he must be." What we are speaking of, Bishop Huntington says, is "a force which runs all through our life, the force of a funded but unreckoned influence, accumulated unconsciously, and spending itself through unconscious developments."

In other words, no one of us can hope to be great by any frontal attack on the citadel of greatness. If we achieve greatness, it will be only because we have forgotten all about that ultimate goal, and have thrown ourselves, heart and soul, into the job of doing the activities of today and tomorrow just as well as we know how, of curbing our tempers and improving our manners in all the little daily contacts of living, of forgetting ourselves and constantly trying to understand others better so that we may serve them more effectively. Only by such means do we build character in ourselves, and only through the character which we have long since built into ourselves are we likely ever to influence others.

Another writer summed all this up in a single sentence. In his "Physics and Politics" Walter Bagehot wrote, also more than sixty years ago, "I can but repeat the truism that it is the lives of teachers that is catching, not their tenets."

I should have hesitated to present all this, which has dealt so exclusively with the problems of my own profession of education, to an audience composed largely of men and women whose academic contacts and interests are far in the past, had I not felt that it has a real and important bearing on other activities than those of a teacher.

In particular I believe, as some of you know, that many of the most interesting and important careers of the engineers of today and tomorrow lie in the field of industrial administration. Engineering-trained men more and more are setting the policies and guiding the destinies of the major industrial enterprises of the day. And under them are other younger engineers occupying every sort of position in those managerial ranks through which the policies of the high command are interpreted to the producing rank and file and implemented into effective action.

Is there not in the industrial field something exactly analogous to this unconscious tuition with which teachers are so familiar? Is it not well known in industry that as the head of a department is, so are his subordinates? Do we not all know of instances in which the fine character of the head of an enterprise is reflected in the morale and unselfish team play of his whole organization, and of other instances where a self-seeking head has bred, as it were, bickering, unhelpful rivalry, and industrial politics in every one under him? Perhaps, then, that which I have been discussing at such length with respect to the educational field may be carried over *in toto* by each one of you into your own field of activity in a way that will help you to develop a philosophy of life of your own, favorable to your own success and comforting to your own soul. By this means you may, perhaps, be better able to recognize and appraise in the industrial field what President Eliot liked to call the "durable satisfactions of life," and, to paraphrase a sentence of David Grayson's, reap as it were a second crop of enjoyment of them by being conscious of the first.

Preprofessional Training

IN A PORTION of his 1938 report, Albert Beecher Crawford, director of the Department of Personnel Study and Bureau of Appointments, Yale University, devoted some space to the adjustment of educational institutions and their students to changing economic trends

"One such trend, mentioned in several preceding reports," he said, "is the increased emphasis placed by prospective employers upon an applicant's definiteness of purpose and, in many instances, upon at least some degree of specific training for business—whether this be along technological lines (such as science and engineering) in management, or in the commercial fields of accounting, marketing, and other aspects of applied economics. . . One need not decry the lasting values of a liberal education in certain respects to recognize that, as business more and more assumes the aspect of a profession, it seeks an appropriate introduction thereto for its future executives. . . . .

"Academic distaste of vocational training and of undue dependence upon *ad hoc* methods of instruction, as compared with learing for its own sake, is a natural attribute of the scholarly mind which characterizes university faculties. However, this emphasis may perhaps be questioned when more than half of the undergraduates at most of our universities, including Yale, are now planning to enter business. A reasonable amount of preprofessional training during this period seems no less desirable for such individuals than for prospective doctors, teachers, or lawyers. One would hardly deny that business, big and little, needs well-trained, progressively minded, intelligent leadership, such as can be advantageously recruited from the college ranks. For those of our youth who hope to furnish this leadership, inadequate orientation to its requirements has as little justification as does excessively narrow specialization at the undergraduate level."

COMBUSTION *of* WOOD-WASTE FUELS

By HENRY KREISINGER

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WOOD-WASTE fuel is refuse material from lumber mills and paper mills and consists of sawdust, shavings, bark, and chopped up trimmings. It contains pieces varying in size from the sawdust to pieces 6 in. long and 2 in. across. It contains on the average about 50 per cent of moisture as fired. The ash is low, usually under 1 per cent.

Waste-wood fuel is used mostly for making steam, and is burned in furnaces of the Dutch-oven type with horizontal or inclined grates. The fuel is supplied through chutes in the roof of the dutch oven and forms a conical pile on the grate about 3 ft high. During the process of combustion the fuel rolls down the sides of the pile to the base of the cone. Air for combustion is supplied through the grate and over the fire through the furnace doors or through special air openings in the side walls, bridgewall, or the arch. A considerable quantity of air also finds its way into the furnace through the fuel chutes with the fuel.

The chemical analysis of waste-wood fuels varies somewhat with the kind of trees from which the fuel was made. The greatest variation is in the moisture in fuel as received. Table 1 gives the chemical analyses of four fuels. The analyses of the first three were made recently by two laboratories on duplicate commercial samples. The two laboratories were the Bureau of Mines, Pittsburgh, Pennsylvania, and the Fuel Engineering Company of New York. The analyses of the two laboratories agree closely. The principal characteristics of the fuels are the high moisture, high volatile matter, and high oxygen contents.

TABLE 1 ANALYSES OF WOOD-WASTE FUELS

Kind of fuel	California —redwood—		Western —hemlock—		Douglas —— fir ——		Pine sawdust
Laboratory	B.M.	F.E.	B.M.	F.E.	B.M.	F.E.	B.M.
Moisture, as received, per cent	50.4	44.3	57.9	57.9	35.9	41.4	...
Moisture, air dried, per cent	7.3	...	7.3	...	6.5	...	6.3
Proximate analysis, per cent of dry fuel:							
Volatile matter	82.5	82.2	74.2	78.9	82.0	82.2	79.4
Fixed carbon	17.3	17.5	23.6	19.5	17.2	17.5	20.1
Ash	0.2	0.3	2.2	1.6	0.8	0.3	0.5
Ultimate analysis, per cent of dry fuel:							
Hydrogen	5.9	5.6	5.8	5.9	6.3	5.8	6.3
Carbon	53.5	53.4	50.4	50.1	52.3	52.5	51.8
Nitrogen	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Oxygen	40.3	40.5	41.4	42.2	40.5	41.2	41.3
Sulphur	0	0.1	0.1	0.1	0	0.1	0
Ash	0.2	0.3	2.2	1.6	0.8	0.3	0.5
Total	100.0	100.0	100.0	100.0	....	1000.0	....
Btu, dry	9920.0	8840.0	8620.0	8290.0	9050.0	8730.0	9130.0

B.M.—Bureau of Mines.
F.E.—Fuel Engineering Company, New York, N. Y.

FUNDAMENTALS OF COMBUSTION OF WOOD-WASTE FUEL

The fundamentals of combustion of wood-waste refuse can be deduced from their chemical analyses and close observation of combustion of wood. Wood-waste fuel contains on the average about 50 per cent moisture, about 40 per cent volatile matter, and little less than 10 per cent fixed carbon. The process of combustion consists of three consecutive and somewhat overlapping steps; namely, the evaporation of the moisture, the distillation and burning of volatile matter, and the combustion of fixed carbon.

The evaporation of moisture and the distillation of the volatile matter absorbs heat. The change of moisture into steam absorbs about 1000 Btu per lb of moisture. The absorption of heat by the distillation of volatile matter is much less, probably not exceeding 200 Btu per lb of volatile matter distilled below 500 F. Part of this heat is used in raising the temperature of the fuel and part in the distillation of volatile matter. Above 500 F the distillation seems to generate a small amount of heat.

The evaporation of moisture takes place at comparatively low temperature not exceeding 212 F, and while there is moisture present all heat absorbed by the fuel is used to evaporate water and the temperature of the fuel cannot be raised above the boiling point of the water. The moisture evaporates as fast as heat is supplied to change the water into steam. After the moisture has been evaporated the heat absorbed by the fuel raises its temperature and the volatile matter comes off at first slowly, but as the temperature becomes higher it comes off at increasingly faster rates. The distillation of the volatile matter goes on whether or not any air is supplied to burn it. It would go on just as well in a gas retort in entire absence of air. The rate of distillation depends on the rate at which heat is supplied for driving off the volatile matter. When the distilled volatile matter is mixed with air and the mixture heated to about 1100 F it bursts into flame and burns.

When most of the volatile matter has been distilled off, the surface of the residue of fixed carbon reaches a glowing temperature and burns as fast as air is brought into contact with it. This is particularly true of the lower parts of the sloping sides of the fuel pile where the surface contains glowing pieces of char from which volatile matter has been distilled. Fixed carbon at the surface of the fuel bed burns mostly to CO_2. However, within the fuel bed the fixed carbon burns to CO, with the air supplied through the grate. The CO_2 that may be formed is quickly reduced to CO by contact with hot carbon. No experimental data are available on this latter phase of combustion of fixed carbon of wood char. However, fairly

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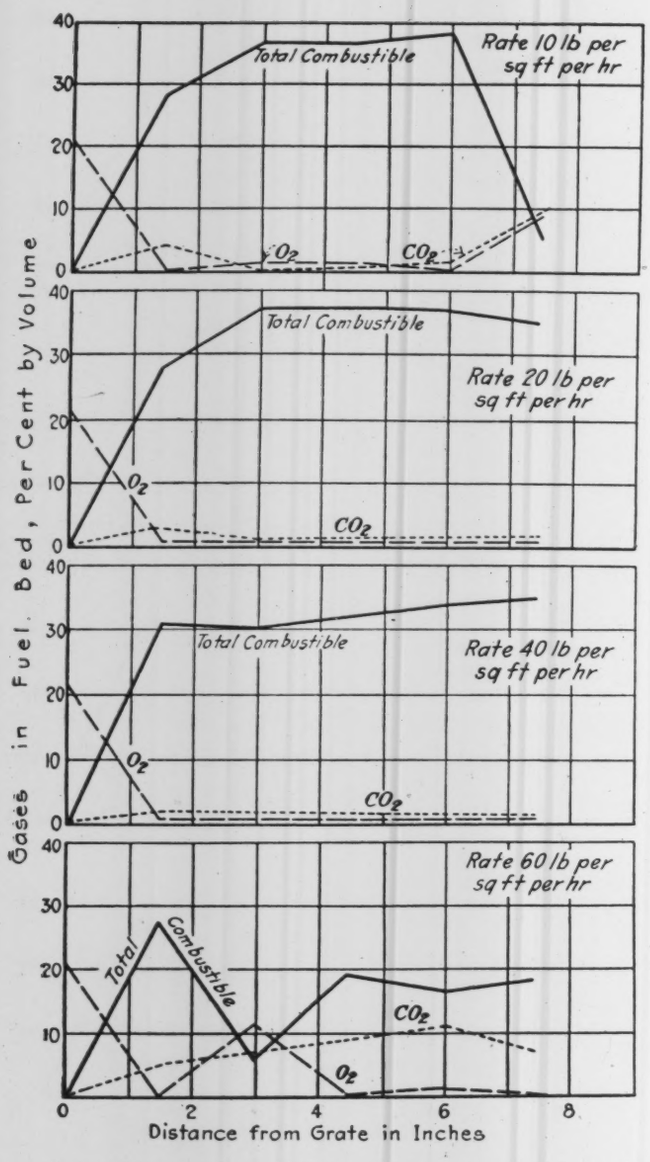

FIG. 1 COMPOSITION OF GASES IN A 6-IN. FUEL BED OF NORTH DAKOTA LIGNITE CHAR

(The horizontal scale gives the height from the grate at which samples of gases were collected for analysis. Five samples were collected simultaneously at the points $1\frac{1}{2}$, 3, $4\frac{1}{2}$, 6, and $7\frac{1}{2}$ in. above the grate. The values obtained by the analysis were connected by straight lines. The charts show that all of the oxygen passing through the grate was used up, and practically all of the CO_2 reduced to CO $1\frac{1}{2}$ in. from the grate.)

accurate deductions can be drawn from the results of experiments with char of North Dakota lignite as illustrated in Fig. 1.

The four charts shown in Fig. 1 give the composition of gases within a 6-in. fuel bed of lignite char obtained by distilling off most of the volatile matter. Each of the four charts gives the gas composition for one rate of combustion; the four rates shown are 10, 20, 40, and 60 lb per hr per sq ft of grate surface. The vertical scale indicates the percentage of each gas, and the horizontal scale gives the distance in inches from the grate at which the sample for analysis was collected. The fuel bed was 6 in. thick and air under different pressures was supplied through the grate to give the desired rate of combustion.

The noteworthy feature is that the oxygen is all used up $1\frac{1}{2}$ in. from the grate, and practically all of the CO_2 has been reduced to CO. The combustible gas is mostly CO with small amounts of hydrogen and traces of methane. At the 60-lb rate of combustion, a uniform fuel bed could not be maintained due to the high velocity of gases through the fuel bed, and the gas composition was erratic. Below this high rate of combustion the flow of air through the fuel bed changed the fixed carbon to CO, which burned to CO_2 when air was supplied above the fuel bed. It is reasonably certain that wood char would behave in a similar way as the lignite char and that air supplied through the grate gasifies the fixed carbon. Increasing the flow of air through the fuel bed only increases the rate of gasification of the fixed carbon without affecting the completeness of combustion.

The important deduction is that all of the combustion of the volatile matter, which constitutes over 80 per cent of the combustible in the wood-waste fuel and about a half of the combustion of the fixed carbon, takes place above the fuel bed. Therefore, about 90 per cent of the air required for combustion should be supplied over the fuel bed and only about 10 per cent through the fuel bed.

COMBUSTION OF INDIVIDUAL PIECES OF WOOD-WASTE FUEL

The various stages of combustion of small pieces of wood such as sawdust follow in rapid succession, and under favorable conditions the process of combustion may be completed within a few seconds. However, with large pieces the process of combustion takes several minutes and may run into hours. Time is required for the heat to penetrate to the central parts of a large piece to evaporate the moisture and distill the volatile matter. The heat conductivity of wood is very low, and the heat transfer from the surface to the central part of the piece of wood is hindered by the presence of moisture and the volatile matter. As the heat penetrates from the surface to the successive inner layers of the wood it encounters the moisture which absorbs the heat and evaporates. The water vapor so formed carries the heat back out of the pieces of wood. As the moisture in the successive inner layers of the wood is evaporated the temperature is raised and the volatile matter changes into gas which in turn carries the heat out. In the case of large pieces of wood the layers near the surface lose all their moisture and volatile matter while there is still a considerable amount of moisture and volatile matter near the center. The loss of moisture and volatile matter causes the outer layer to shrink and the stresses so produced cause the surface layers to crack with noticeably loud reports and the flying of broken pieces of the cracked surface. The steam and volatile matter escape from the inner parts of the wood through the cracks and the combustible gases burn with a bright flame. As the evaporation of moisture and distillation of volatile matter in the central part of the larger pieces of wood goes on, the cracks in the outer layers become wider and deeper and finally the large pieces of wood disintegrate into small pieces of char which complete their combustion at the base of the fuel pile, with the air supplied through the grate.

The natural ash in the wood-refuse fuel is a very low percentage of the fuel fired, but becomes much more concentrated in the char after the moisture and volatile matter has been driven off. As the fixed carbon is burned off from the char, the ash is left on the surface as a layer of light, porous, and very friable material. In a boiler furnace some of this ash is torn off and carried out of the furnace by the moving gases. The remainder of the ash finds its way into the ashpit.

Besides the natural ash, wood-waste fuel contains earthy material that was not originally in the trees, but was added during the log, cutting and transportation operations, particularly if the logs were floated in muddy rivers or salt-water

bays. This added ash is heavier and tougher than the natural ash and some of it stays on the grate as clinkers.

RATE OF COMBUSTION

The high moisture content greatly hinders the speed of combustion of wood-waste fuels. As long as there is any moisture in the fuel its temperature cannot be raised to a point at which a large part of the volatile matter is driven off and ignited. With the average fuel, about 1 lb of moisture per lb of dry fuel must be evaporated before any burning can occur. Dry wood burns easily in open fires with no refractories around it, or, in completely water-cooled furnaces. We light fires with dry wood because it ignites readily and burns quickly.

Wood-waste fuel can be burned as fast as the moisture and the volatile matter can be driven off, and moisture and volatile matter is driven off as fast as heat can be supplied for the evaporation of moisture and the distillation of volatile matter. It can be said then that a wood-waste fuel can be burned as fast as heat can be supplied for the evaporation of moisture and the distillation of volatile matter.

Heat is supplied to the freshly fired fuel by radiation from the flame of already distilled and burning volatile matter and from the hot furnace walls and arches. Heat is also supplied by convection by sweeping the burning volatile matter over the freshly fired fuel or by dropping the fuel into the furnace through the burning volatile matter. The rate of heat transfer by radiation depends on the temperature of the heat-radiating bodies, and the rate of heat transfer by convection depends on the temperature of the gases and the velocity with which the hot gases are swept over the freshly fired fuel.

The furnace temperature depends on the moisture content of the fuel as fired, on the amount and the temperature of the air supplied for combustion, and on the rapidity of air mixing with the distilled volatile matter. Moisture requires heat for its evaporation and for raising the temperature of the vapor to the furnace temperature; both the latent heat and the specific heat of water vapor are high. The heat absorbed by the moisture reduces the quantity of heat available for raising the temperature of the products of combustion.

All the air required for the combustion of the volatile matter should be supplied close to the surface of the fuel pile and with sufficient velocity to produce rapid mixing with the distilled volatile matter. The quick combustion produced by rapid mixing concentrates the intensity of burning to a comparatively small space above the fuel pile and results in high temperature which in turn causes a higher rate of heat transfer to the freshly fired fuel and more rapid evaporation of the moisture and distillation of its volatile matter.

EFFECT OF SIZE OF FUEL PARTICLES

The surface of a freshly fired fuel receives heat by radiation and convection from the already burning volatile matter. From the surface the heat travels by conduction to the inner parts of the piece. Large pieces of fuel have a comparatively small surface and a large interior mass to which heat must be transferred by conduction. Inasmuch as the heat conductivity of wood is low, it takes a longer time to drive off the moisture and the volatile matter from a single large piece of fuel than several smaller pieces of equal total weight. A bunch of excelsior or wood shavings burns in a few seconds because they have a very large surface to receive heat and practically no interior to which heat must be supplied by conduction. A stick of wood takes several minutes and a log in a fireplace takes several hours to burn, because they have a small surface to receive the heat and a large interior mass to which heat must be transferred by conduction to drive off the moisture and the volatile matter. The surface at first receives heat by radiation and by convection. After the volatile matter has been distilled from the surface layer, the temperature of the layer is raised and the surface begins to glow. If oxygen has access to the surface the fixed carbon burns and heat is generated at the surface and transferred to the inner parts. As the fixed carbon burns off, a layer of fluffy ash is left at the surface of the piece of wood or a log. This fluffy layer of ash is a hindrance to heat transfer and also to the heat generation because it prevents the oxygen making contacts with the fixed carbon underneath the layer of ash. If there is an intensive turbulence of the gases and air above the fuel bed, the layer of ash may be torn off and carried away by the gases, and expose the fixed carbon to contact with oxygen, or, absorption of heat by radiation and convection. In an open grate fire, where no turbulence is provided to remove the layer of ash, the latter accumulates on the surface and unless it is scraped or shaken off with a poker the fire goes out.

Therefore, the size of the pieces of fuel has a marked effect on the rapidity of combustion. Wood-waste fuel should be chopped up into reasonably small pieces to increase the surface and to reduce the amount of combustible inside of the pieces to which heat must be transmitted by conduction for driving off moisture and volatile matter, and to which oxygen must be supplied through a layer of ash to burn the fixed carbon.

FEEDING OF FUEL TO THE FURNACE

When wood-waste fuel is fired by dropping it into a furnace, excessive amounts of very fine pieces may be objectionable because many of these small pieces are caught by the moving gases and carried out of the furnace only partly burned. It would be better to fire such fuel by pushing it into the furnace either through the sides or through the bottom of the furnace in such a way that the small pieces would not be put in suspension in the moving gases. While a small amount of agitation of fuel pile is desirable, because it helps to remove the ash and thereby exposes the surfaces to the action of heat and oxygen, excessive agitation causes a large amount of partly burned small pieces of fuel to be carried out of the furnace.

EFFECT OF MOISTURE IN FUEL ON THE TEMPERATURE OF COMBUSTION

The moisture in the fuel is the greatest factor affecting the temperature of combustion. The effect of moisture on the temperature of combustion of California redwood fuel is shown in Fig. 2. The amount of moisture is expressed in two ways, weight of moisture per pound of dry fuel, and per cent of moisture in fuel as fired. The bottom curve shows the maximum temperatures of combustion obtainable with 20 per cent excess air; the air is supplied at a temperature of 70 F. The middle curve shows the maximum temperature with 83.3 per cent of the air passed through the air heater and preheated to 600 F. The remaining 16.7 per cent of air was assumed to leak into the furnace and setting at 70 F; this is a good performance for an air-heater installation. The top curve gives the maximum temperature of combustion with an air heater receiving gases at 700 F, preheating 83.3 per cent of the air used for combustion to 600 F. After leaving the air heater the gases flow through a drier where their temperature is reduced to 175 F, and the heat abstracted is used for partly drying the fuel. For example, with an original moisture in the fuel of 1.5 pounds per pound of dry fuel, the temperature of the gases was reduced from 700 F to 423 F on passing through the air heater and preheating 83.3 per cent of the air to 600 F. After leaving the air heater the gases were passed through a fuel drier where their temperature was reduced from 423 F to

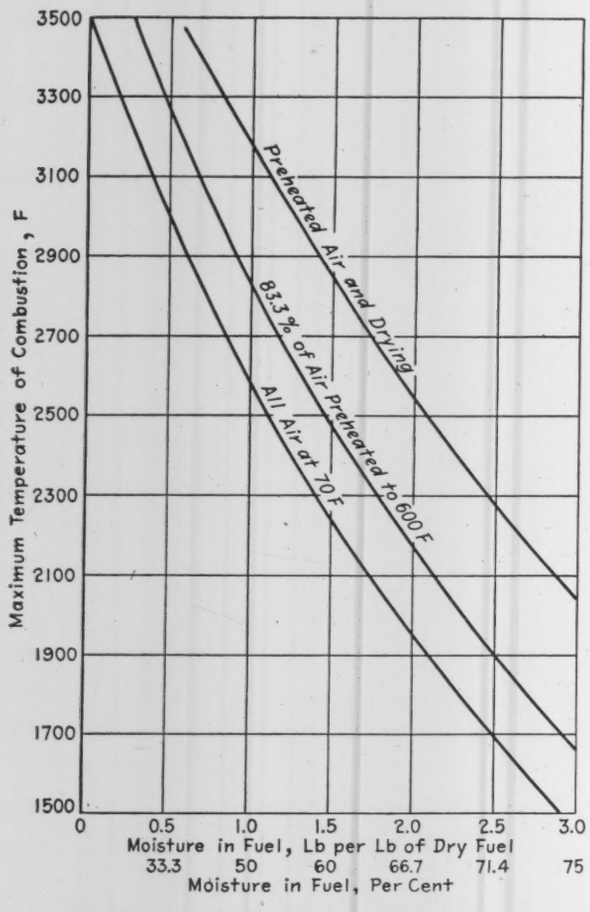

FIG. 2 MAXIMUM OBTAINABLE TEMPERATURE OF COMBUSTION WITH FUELS OF DIFFERENT MOISTURE CONTENTS

(The bottom curve gives the temperature when the air used in combustion was supplied to the furnace at 70 F. The middle curve gives the temperature with 83.3 per cent of the air supplied for combustion preheated to 600 F and 16.7 per cent entered the furnace at 70 F. The top curve gives the temperature for preheated air as in the second case, but in addition the fuel was preheated and partly dried by passing the gases from the air heater through a fuel drier, which reduced their temperature to 175 F.)

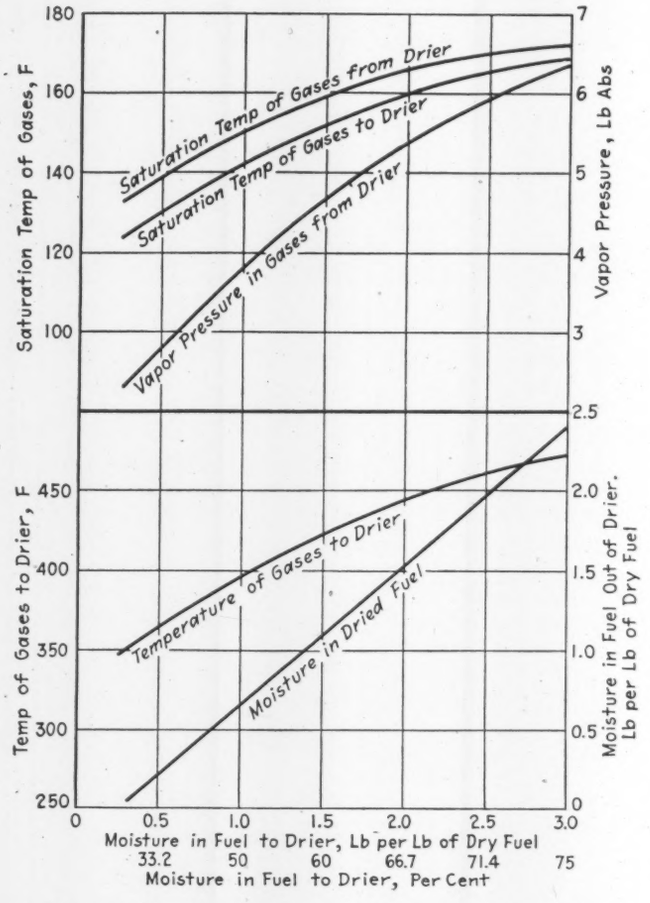

FIG. 3 EFFECT OF MOISTURE CONTENT IN THE FUEL ON VARIOUS FACTORS OF THE DRYING PROCESS

(The lowest curve with the lower scale at the right gives the amount of drying obtainable when the gases leaving the air heater are passed through the drier, and their temperature is reduced from that indicated by the second curve from the bottom to 175 F. The two top curves give the saturation temperature of the gases entering and leaving the drier. The water vapor pressure within the fuel must be higher than the vapor pressure in the gases if drying of fuel is to take place.)

175 F. The heat abstracted from the gases is used to heat the wet fuel and to evaporate part of the moisture. The temperature of gases entering the drier, and the amount of moisture evaporated are given by the two lowest curves in Fig. 3. With lower moisture in the fuel there is less water vapor in the gases passing through the air heater; therefore, there is a greater reduction in their temperature to heat 83.3 per cent of the air to 600 F. The weight of gases passing through the air heater decreases with decreasing moisture in the fuel, whereas the weight of air remains constant. Since the temperature of gases entering the drier becomes lower with decreasing moisture in the fuel, less moisture is dried out when the moisture in the fuel to the drier is lower.

The temperature of combustion drops rapidly with the increased moisture in the fuel. Thus, when the moisture is increased from 50 to 60 per cent, the temperature of combustion drops about 340 F. This drop in temperature greatly reduces the rate of heat transfer to the freshly fired fuel, thereby reducing the rate of distillation of the volatile matter and the rate of combustion. The probable practical lower temperature limit is about 2000 F. This temperature would set the high moisture limit at about 65 per cent when an air heater and a drier are not used, about 70 per cent with an air heater, and about 75 per cent when both an air heater and a drier are used. The combustion at these high moisture limits would be slow, the burning capacity of a furnace low, and the operation of the burning and drying equipment would be troublesome. When the moisture in fuel runs over 55 per cent, an air heater becomes very useful because it raises the efficiency, and, what is usually more important, the capacity of the burning equipment. When the moisture runs over 60 per cent, a drier is advisable; if it runs over 70 per cent a drier is necessary.

The principal object of a reasonably high temperature of combustion is to make it possible to burn the fuel at sufficiently high rates so that the rates of combustion can be regulated to meet variable demands for steam.

PREHEATING AIR

As pointed out, preheating the air used for combustion to 600 F raises the temperature of combustion 200 F to 250 F. A higher temperature of preheated air would be desirable. It is limited by the temperature of gases entering the preheater which must be at least 100 F higher than the temperature of the preheated air, otherwise the air heater would have to be very large and expensive. A higher temperature of gases to the air heater would reduce the size of the air heater; also, it might be used to give somewhat higher temperature of the preheated air.

Because the weight and the specific heat of the gases are greater than the weight and the specific heat of the air, the temperature drop of the gases while passing through the heater is much smaller than the temperature rise of the air. Thus, with a fuel containing 50 per cent moisture, a gas-temperature drop of 305 F is accompanied by an air-temperature rise of 530 F, which is a difference of 225 F. This difference increases with the moisture content of the fuel, and also with the amount of unheated air entering the furnace and setting. With the usual method of firing by dropping the fuel into the furnace through chutes in the arch, a large amount of air enters with the fuel, and it is mechanically difficult to supply preheated air in this manner. By pushing the fuel into the furnace through the bottom or sides, the entrance of unheated air with the fuel could be practically eliminated.

DRYING FUEL

Inasmuch as the temperature drop of the gases while passing through the air heater is small, the gases leaving the air heater contain a considerable quantity of heat which could be used for predrying the fuel before it is supplied to the furnace. Such predrying of the fuel would materially reduce the temperature of gases and thereby increase the efficiency of the steam-generating equipment. It would also raise the temperature of combustion, thereby making it possible to burn more fuel in a given furnace size. Very wet fuels which at present have little commercial value could be utilized for making steam and thus more than pay for their disposal.

The wet fuel can be dried by passing the hot gases through the fuel. The fuel drier could be arranged so that the fuel passes through it on its way to the furnace, and the hot gases would pass through the fuel on their way from the air heater to the stack. It would be possible to reduce the temperature of the gases to about 175 F. The heat abstracted from the gases would be utilized in vaporizing part of the moisture and preheating the fuel before it entered the furnace.

DRYING PROCESS

In order that a part of the moisture may be driven off during a drying process, the fuel must be heated above the dewpoint of the gases used for drying. Raising the temperature of the fuel above the dewpoint or saturation temperature of the gases raises the vapor pressure within the fuel above the vapor pressure in the gases and this difference in pressure drives part of the moisture from the fuel. The moisture driven from the fuel raises the saturation temperature of the gases so that the temperature of the fuel must keep on rising to maintain the vapor-pressure difference necessary for drying. The heat required to evaporate the moisture and to raise the temperature of the fuel is taken out of the gases, and their temperature drops. This drop in gas temperature slows down the heat transfer from the gases to the fuel and thereby reduces the rate of drying. The drying stops when the temperature of gases is reduced to the saturation point.

The various factors of the drying process are shown graphically in Fig. 3. The horizontal scale which gives the moisture in fuel to drier applies to all curves. The lower figures of this scale indicate the percentage of moisture in fuel as delivered to the drier, and the upper figures the moisture in pounds per pound of dry fuel. There are four vertical scales: The lower scale at the right applies to the lowest curve and gives the moisture in dried fuel. The lower scale at the left applies to the second curve from the bottom which gives the temperature of gases to drier. This temperature is reduced to 175 F while the gases pass through the drier. The third curve from the bottom gives the partial vapor pressure in the gases leaving the drier, as indicated by the upper scale at the right. The upper scale at the left applies to the two top curves, which give the saturation temperature of the gases to and from the drier.

The amount of moisture that can be dried out of the fuel depends on the temperature of gases leaving the air heater, which temperature depends on the moisture in the fuel. It is assumed that the gases leave the boiler at a temperature of 700 F and that 83.3 per cent of air used in combustion is preheated to 600 F. It is a question as to how high the temperature of gases entering the drier could be for the best results. If it were too high, the fuel with which the gases first come in contact might lose most of its moisture, become overheated, and a part of the volatile matter might be driven off.

The principal benefits derived from the use of a drier are, first, the reduction of the temperature of exit gases to a very low point, and, second, the raising of the temperature of combustion, thereby making possible higher rates of combustion and fuller utilization of the steam-generating equipment.

FLOW OF FUEL THROUGH A DRIER

Successful drying requires a uniform flow of the fuel through the drier. If the fuel were to hang, it may become overheated and part of the volatile combustible might be lost. The high percentage of CO_2 and water vapor in the drying gases

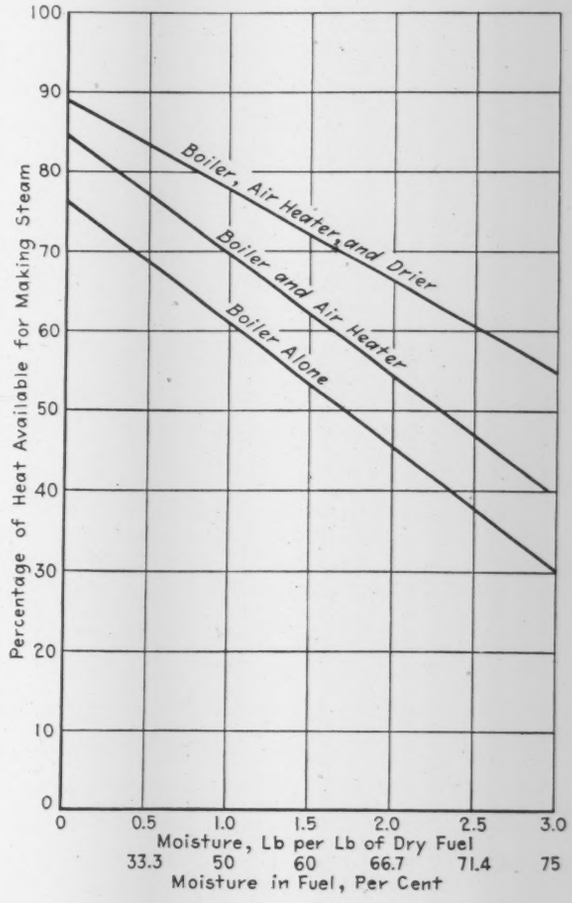

FIG. 4 EFFECT OF MOISTURE CONTENT IN THE FUEL ON THE PERCENTAGE OF HEAT AVAILABLE FOR MAKING STEAM WITH THREE COMBINATIONS OF STEAM-GENERATING EQUIPMENT

(The lowest curve is for a boiler alone with the temperature of the gases leaving the boiler at 700 F. The middle curve is for a boiler equipped with an air heater which preheats to 600 F 83.3 per cent of the air used in combustion. The third curve is for the same boiler, equipped with an air heater and a fuel drier, the temperature of the gases leaving the drier having been reduced to 175 F.)

greatly reduces the chances of fire. The flow of the fuel through the drier should be better with a uniform distribution of sizes of the fuel pieces. A uniform mixture of sizes should also result in better distribution of gas flow through the fuel. Large pieces should be avoided because they might cause stoppage in the conveying machinery, hanging in the drier, and slow down the drying process. Moisture in drying is taken mostly from the surface. Large pieces have small surface for giving up moisture during the drying process; they should be reduced in size before they are delivered to the conveying and drying apparatus.

EFFECT OF MOISTURE IN FUEL ON EFFICIENCY

When wood-waste fuels are used for generating steam the amount of heat available varies inversely as the moisture content of the fuel. The higher the moisture in the fuel the less heat is available per pound of dry fuel, and the lower is the steam-generating capacity of the equipment. Fig. 4 shows the effect of moisture in fuel on the percentage of heat available for generating steam with three types of equipment. The horizontal scale gives the moisture in fuel, and the vertical scale gives the percentage of heat in fuel available for making steam. The bottom curve gives the available heat with a boiler alone without economizer, air heater, or drier. The temperature of gases leaving the boiler is assumed to be 700 F and the fuel is burned with 20 per cent excess air. It is further assumed that 1 per cent of the heat is lost by radiation, and 2 per cent is lost in incomplete combustion. The middle curve gives the available heat when the boiler is equipped with an air heater, and 83.3 per cent of the air used in combustion is preheated to 600 F. The top curve gives the available heat when the boiler is equipped with an air heater and a drier. The benefits derived from the use of an air heater and a drier increase with the percentage of moisture in the fuel. Thus, for example, with a fuel containing 50 per cent moisture, or 1 lb of moisture per lb of dry fuel, if it takes 100 tons of fuel on the dry basis to produce a required quantity of steam with a boiler alone, it will take only 87 tons of fuel with a boiler and air heater, and 78.6 tons if the boiler were equipped with an air heater and a drier. This is a saving of 13 and 21.4 per cent in fuel.

With a fuel containing 66.7 per cent moisture or 2 lb of moisture per lb of dry fuel, it will be necessary to burn 134.5 tons of fuel on the dry basis to produce the same quantity of steam with a boiler alone, 112.5 tons with a boiler and an air heater, and 91.7 tons with a boiler, an air heater, and a drier. This is a saving in fuel of 16.4 and 31.6 per cent, respectfully.

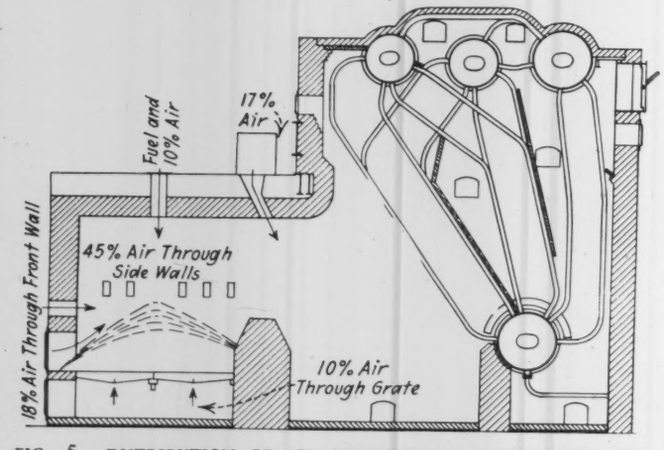

FIG. 5 DISTRIBUTION OF AIR SUPPLY IN A DUTCH-OVEN TYPE FURNACE FOR BURNING WOOD REFUSE FUELS FOR MAKING STEAM WITH THREE COMBINATIONS OF STEAM GENERATING EQUIPMENT

Comparison of the quantity of fuel that must be burned with the two moisture contents to produce a given quantity of steam shows conclusively that it pays to select fuel with low moisture content, and make every effort to prevent the fuel from absorbing moisture.

Fig. 5 shows the distribution of air in the conventional design of a furnace for burning wood-waste fuel. The furnace is of the Dutch-oven type with a secondary combustion chamber under the boiler. The fuel is dropped into the furnace through fuel chutes in the roof of the furnace. There is usually one of these chutes for every 5 or 6 feet of furnace width.

Ninety per cent of the air used in combustion is supplied over the fuel bed and 10 per cent through the grate. The air supplied over the fuel bed burns the volatile matter which constitutes over 80 per cent of the dry fuel. It also burns the CO formed from the fixed carbon in the fuel bed by the passage of 10 per cent of the air through the grate. As pointed out in connection with Fig. 1, fixed carbon in a fuel bed burns to CO. If attempt is made to burn the carbon to CO_2 by supplying more air through the grate more carbon is changed to CO gas without a measurable amount of CO_2 being formed. That is, the fuel bed acts as a gas producer, and the rate of gasification of fixed carbon is determined by the rate of flow of air through the grate.

The air flow through the grate is used to control the thickness of the fuel bed. If the fuel bed is too thick, it can be thinned down by increasing the flow of air through the grate; if it is desired to increase the thickness, the flow of air is reduced.

The fuel bed is in the shape of a ridge consisting of a number of cones equal to the number of fuel chutes; it is a fuel pile rather than a fuel bed. A fuel bed in connection with coal burning is understood to be a layer of burning coal of a nearly uniform thickness. The ridge-shaped fuel pile of waste-wood fuel is incidental to the method of supplying fuel to the furnace, and has the advantage of a large surface for receiving heat which is required to drive off the moisture and the volatile matter.

The air over the fuel bed should be supplied in such a way that it is readily mixed with the volatile matter as the latter comes off the freshly fired fuel. The illustration shows 18 per cent of the air supplied through the furnace front, 45 per cent through the side walls, 10 per cent with the fuel, and 17 per cent through the rear part of the arch. If the total air supplied by combustion includes 20 per cent excess, then 83 per cent of the total air represents the amount theoretically needed for combustion, and the 17 per cent is the excess air. The air supplied with the fuel is accidental because it is difficult to keep out. The air through the furnace front may be increased and through the side walls reduced with wider furnaces. The air through the rear part of the arch is directed about 30 degrees from the vertical and should be supplied at sufficient pressure to push the burning mixture into the lower part of the secondary combustion chamber under the boiler. The front and side-wall air should be also supplied under a pressure to produce intensive mixing over the fuel pile so that most of the combustion would take place in the space between the arch and the fuel pile. This space is made large to accommodate such mixing and combustion. Combustion in this space makes the heat generated available for driving the moisture and volatile matter from the freshly fired fuel. If the steam generating unit includes an air heater, it is easy to provide preheated air under pressure at all points excepting perhaps that entering the furnace with the fuel.

Preheated air increases furnace maintenance. The grate is subject to overheating because some of the char drops through the grate and burns in the ashpit. Water cooling the grate, the front wall, and the arch would eliminate excessive maintenance without appreciably affecting the combustion.

ECONOMICS *of a* POWER PLANT *for Joint Utility and Industrial Service*

By AUGUST C. KLEIN[1] AND THOMAS E. CROSSAN[2]

IT IS never possible for an industrial business enterprise, particularly one enjoying a growth in business, to install a power plant in which the production of steam and of by-product electricity can be exactly balanced to its requirements. This is because the requirements for each vary hourly during every day, and more substantially from season to season. Growth in business or changes in industrial processes also continually bring about changes in steam and electric-power requirements. This constant unbalance in steam and electrical requirements makes it necessary for the industry designing its own power-plant facilities to do so on a compromise basis which inevitably results in higher cost of plant operation. Either steam must be wasted at times or the plant must install condensing equipment or purchase power to supplement its own production.

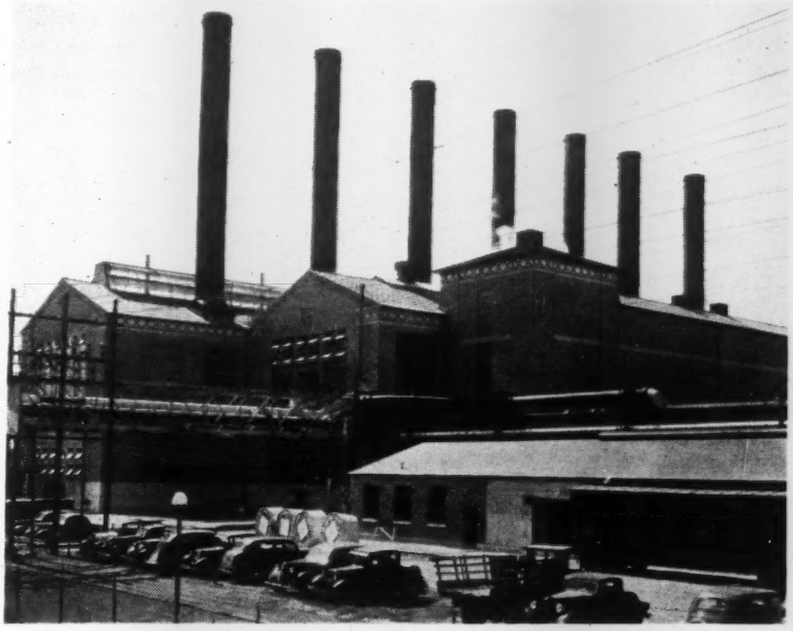

FIG. 1 LOUISIANA STATION OF GULF STATES UTILITIES COMPANY
(Containing seven boilers and five turbines rated at 2,800,000 lb of steam per hr and 95,000 kw.)

On the other hand, the industrial plant which is fortunate enough to arrange with a neighboring public-utility system for the joint generation of their total steam and electric-power requirements is able to participate in the savings made possible by the joint operation. These result partly from the larger scale of operations, but principally from the ability to utilize all of the by-product energy which the process-steam requirements of the industrial plant can produce.

The Louisiana Station of the Gulf States Utilities Company at Baton Rouge, La., is an outstanding example of the possibilities of the use of a power plant for joint industrial and public-utility service. This station, shown in Fig. 1, is today the largest station of its kind in the United States. Every year since 1930, when it began operation, it has sold more process steam and has generated more by-product energy from process steam than any other station operating under similar conditions. Its output for each year of its operating life is shown on Figs. 2 and 3. Future expected steam and by-product electric outputs are based on contractual obligations and steam load factor of 80 per cent.

During the first ten months of 1938, the station generated steam at a higher rate than during any corresponding period in its history. The same is true of its by-product electric generation. During this period, the generation of steam was at a rate exceeding ten billion pounds per year. Steam sales were at a rate exceeding eight billion pounds per year, and the generation of by-product electrical energy, at a rate exceeding three hundred million kilowatt hours. Approximately 39 kwhr of electric energy were generated for each thousand pounds of steam sold. The maximum steam generation for the period was at the rate of 1,450,000 lb per hr, and the maximum generation of by-product electrical energy was 45,000 kw. The station load factor for both steam and electrical operation was 82 per cent.

The plant thermal efficiency for the period, or the ratio between the sum of the heat in the steam sold and the heat in the net by-product electrical energy generated to the heat content of the fuel consumed, was approximately 78 per cent. This compares with approximately 31 or 32 per cent in the most modern high-pressure steam power plants.

HISTORY OF THE LOUISIANA STATION

The Louisiana Station is located on the Mississippi River about 6 miles north of Baton Rouge, La. The initial construction was started in October, 1929. In May, 1930, the plant began to deliver steam and power to an adjacent oil refinery and to the public-utility system in Baton Rouge. The original plant consisted of four cross-drum boilers, each rated at 350,000 lb of steam per hr and operating at 625 lb per sq in. gage pressure and 725 F. Three 15,000-kw noncondensing turbines were installed, exhausting at 140 lb per sq in. to the process-steam system. Except for the addition of one boiler with a capacity of 400,000 lb of steam per hr in 1931, only minor changes were made to the plant up to 1937, at which time the construction work now in progress was begun. The ex-

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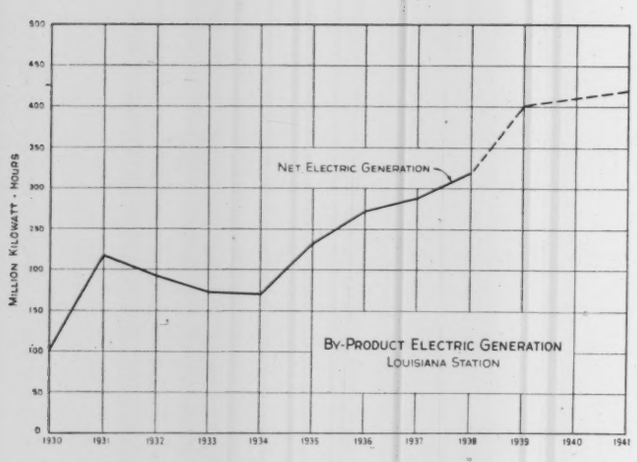

FIG. 2 BY-PRODUCT ELECTRIC GENERATION, LOUISIANA STATION

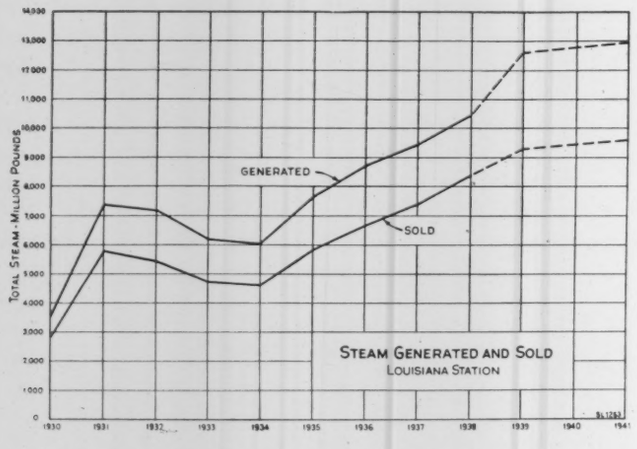

FIG. 3 STEAM GENERATED AND SOLD, LOUISIANA STATION

tension now under construction includes two boilers each with a capacity of 500,000 lb per hr and two 25,000-kw turbine generators of combined condensing-and-extraction type. The extension will involve no change in steam conditions.

From the start, the plant has operated with high make-up, necessitating an extensive feedwater treating plant and a considerable amount of boiler blowdown. The plant has also continuously utilized several types of oil-refinery wastes, including petroleum coke and oil sludges.

SUMMARY OF CONTRACT CONDITIONS

Louisiana Station supplies steam at a pressure of 140 lb per sq in. and electricity at 13,800 v to three major industrial customers, an oil refinery and two chemical plants. The conditions surrounding the delivery of its products to these customers vary so considerably that a statement of them is necessary as a preliminary to further discussion of the contract details.

The contract with the oil refinery is based upon a maximum guaranteed steam demand of 975,000 lb per hr and a maximum electric demand of 22,425 kw. This is a ratio of 23 kwhr of electrical energy for each 1000 lb of steam purchased. The refinery is obligated to furnish fuel in proportion to its use of steam. At least 50 per cent of this fuel is specified to be natural gas or fuel oil, and the other 50 per cent may be furnished in the form of one or more of the several by-product fuels which result from refinery operations. These comprise refinery gas, the delivery of which is limited by the contract to a maximum of 25 per cent of the fuel to be furnished by the refinery, and oil sludge and petroleum coke which are limited to maxima of 25 per cent and 10 per cent, respectively. Another factor which has been considered in the contract is the fact that the refinery has a reserve boiler plant which it maintains in readiness to operate upon request.

One of the chemical-plant customers has a guaranteed maximum process steam demand of 176,000 lb per hr and a maximum electric demand of 8576 kw. This is a ratio of 49 kwhr of electrical energy for each 1000 lb of steam taken. The chemical plant produces no by-product fuels; therefore, its fuel supply is specified to be delivered in the form of natural gas normally with the option of furnishing commercial fuel oil in emergency. This plant has no reserve boiler-plant equipment.

The second chemical plant has a guaranteed maximum steam demand of 270,000 lb per hr and an electric demand of 25,000 kw. This is equivalent to 92 kwhr for each 1,000 lb of steam taken. Its produces no by-product fuel and also contracts to furnish natural gas as a normal fuel or fuel oil in emergency. It has no reserve boiler plant.

The Louisiana Station was constructed to serve the oil refinery, and the initial contract was drawn on the premise that approximately one half of the by-product energy generated by process steam would be needed for refinery uses and that the other, or surplus half, would be sold to public-utility systems associated with the Louisiana Station. In the case of the chemical plants, however, this condition does not exist. Plant no. 1 has power requirements slightly in excess of the entire amount of power that can be generated from the steam which it consumes. The second chemical plant has power requirements of more than double the amount of energy which its process steam will generate. When the load of the first chemical plant was connected it was possible for the station to divert to it part of the excess electrical energy produced from the oil-refinery steam, but when the load of the second chemical plant was offered it was so large in proportion to its own steam requirements and to the remaining excess energy from the oil-refinery steam that the installation of combined extraction-and-condensing turbine generators was necessary.

This difference in the ratio of the steam to electric requirements of the oil refinery and of the two chemical plants made it necessary to draw up somewhat different forms of contract for them. The summarized provisions of these contracts are:

In all cases the industrial plants assume the responsibility for a part of the fixed charges of that part of the station which is reserved for their use. This is done through the application of demand charges having a fixed monthly minimum and also through the application of minimum monthly bills. These demand charges give consideration to the relative investment involved in the condensing and noncondensing portions of the station.

All three industries also contract to furnish the fuel necessary for the generation of the steam which is generated for their use. In all cases the amount of fuel to be supplied is specified to be 1,600,000 Btu for each 1000 lb of process steam taken. This amount of heat is very close to the quantity which the station consumes in generating steam for the use of its process-steam customers. In addition, the three customers pay a service charge for each 1000 lb of process steam which they take.

To the extent just described, all three contracts are generally similar. With respect to the charges for electrical energy, however, the approach is different for the three customers. This difference arises from the fact that the refinery steam generates an excess of energy over its demands, while the chemical-plant steam does not produce enough electrical energy to satisfy its requirements.

In the case of the oil refinery, the intent of the contract is to reserve the excess by-product energy for the use of the utility.

Accordingly, a low rate is fixed as the charge to the oil refinery for a block of energy equal to one half of the amount estimated to be generated from its process steam. To take care of unavoidable swings in the refinery electrical load, provision is made whereby the refinery may increase its takings of energy at a nominal increase in the base rate up to an amount of 15 per cent in excess of its base requirements. Any energy which it takes beyond this amount is billed at a substantially higher rate and one that conforms with the cost of condensing generated power. This basis of charging for electrical energy was used in the original contract which was made nearly ten years ago, and it has proved so successful that the principle has been used without change in a new 12-year contract which has just been executed.

The approach to the contracts with the chemical companies has been from an entirely different angle. These companies resemble more nearly the other large customers of the company and the rate at which they are billed for electrical energy is a form of standard block rate in which the first block of energy is billed at a fair base rate with lower rates for additional increments of energy. The rate schedule is similar to the usual demand and commodity schedule, having the blocks in the commodity portion of the rate based on the load factor corresponding to the coincident demand. Recognition is given to the contribution which the process-steam purchases of the chemical customers make to the economy of operating the station. This is done by a clause in the contract which provides for a credit to their electrical bills; this credit is a fixed amount for each 1000 lb of steam taken by the chemical plant. The contracts also recognize the fact that electric power is purchased at generator bus voltage and at the station walls, thereby eliminating transmission investment and operating costs. All transactions with each of the three customers are on a monthly basis. Demand charges are not based on the so-called ratcheted-demand principle, and all other transactions are based on a monthly operating period.

In the case of the oil-company contract, one of the important considerations was the ability of the refinery to dispose of, and the ability of the utility to utilize, several grades of nonmerchantable but burnable fuels. In the initial contract the quantity of each such fuel to be burned and a fixed price per million Btu were specified for each. These prices varied, depending on the difficulty of burning each particular fuel. Fuel oil commanded the highest price as its combustion involved no difficulty. Petroleum coke, a high-grade fuel, required pulverization, and its price was accordingly lower than that of fuel oil by an amount which represented the cost of pulverizing it. Refinery sludges, which were most difficult to handle and which frequently contained up to 50 per cent moisture, as well as substantial quantities of corrosive acids, commanded a still lower price per million Btu to compensate for the added difficulty of handling them as well as the reduced efficiency of combustion introduced by the large quantities of water which they contained.

During the eight years of operation under the old contract, sufficient knowledge was obtained about the combustion of the several sludges and of petroleum coke so that the simpler provisions controlling the supply of fuel were agreed upon for the new contract.

ADVANTAGE OF JOINT OPERATION TO INDUSTRIAL CUSTOMERS

In many cases, the industrial enterprise which is served by a jointly operated power plant is able to reduce its total capital investment because no part of its capital has to be invested in power-plant buildings or equipment. The removal of the power plant from the industrial site also makes available additional space for manufacturing buildings and operations. As an example, the two chemical enterprises which are served by the Louisiana Station contracted for their steam and power supply before the beginning of plant construction. They were thereby enabled to avoid the capital expenditures for steam and electric-generating equipment; also, they were enabled to lay out their plants more compactly and with a better utilization of the available plant site.

In other cases, an industrial enterprise is enabled, if connected to a jointly operated plant, to avoid capital expenditures for replacing worn-out equipment or for extending its facilities to provide for expected load growth. Conversely, usable but uneconomical power-plant equipment of the industrial may frequently be used for emergency or peak-load service, and its use in that manner permits a reduction in the investment required for the jointly operated plant. These conditions prevailed in the case of the oil refinery served by the Louisiana Station. In 1930, the refinery was faced with expenditures for remodeling and extending its boiler plant. The construction of the Louisiana Station made this expenditure unnecessary, although the existing plant continues to serve a useful purpose as a reserve for the more economical equipment in the Louisiana Station.

From an operating standpoint, freedom from power-plant problems is a decided advantage to any industrial enterprise. Its executives, by being relieved from power-plant operating troubles, can concentrate their activities along the more profitable lines of directing the primary functions of their business. This is particularly true because the reliability of steam and electric-power service to the industrial plant is almost invariably greatly improved when served by a jointly operated plant. This is because of the usually higher standard of design, maintenance and operation which prevails in public-utility power stations.

In many cases, the industrial plant has considerable quantities of waste or by-product fuels which have a substantial heat value and which can be burned to generate steam, although frequently the process of combustion is difficult. Among such fuels are lumber wastes, bagasse, tan bark, combustible gases, and various kinds of oil-refinery waste. The oil refinery served by the Louisiana Station produces substantial quantities of refinery gas, petroleum coke, and several qualities of oil sludge. Before the construction of the Louisiana Station, some of these products were being burned with more or less success under the refinery boilers. However, great piles of petroleum coke had accumulated, and much of this material was being sold at relatively low prices. The plant also produced some sludges which it could not burn at all. The designers of the Louisiana Station agreed to consume all of these fuels, and they have not only handled the current production of the refinery, but have also completely used up the stock of petroleum coke that was on hand when the plant started. This transaction has been of considerable benefit to the oil refinery because it enabled the refinery to dispose of considerable quantities of otherwise unsalable fuel, and to be relieved of the troubles attendant upon burning them under its own boilers. The application of advanced engineering in the design and operation of the Louisiana Station enables those fuels to be handled in the most economical manner possible, and the results of that economy are shared by the oil refinery.

Any industrial plant will also derive an advantage in its operations when the plant is completely freed from smoke, coal dust, and ashes. In some industrial processes, this may be a factor of major importance. In addition, the industrial plant participating in the operation of a joint power plant also participates in the over-all operating savings produced through the use of its process steam for generation of by-product power.

All of these advantages may be summarized by the statement that participation with a public utility in the joint operation of

a plant to generate steam and by-product electrical energy should enable any industrial enterprise to produce a better, lower-cost product than would be possible if it were operating its own power plant.

ADVANTAGES OF JOINT OPERATION TO PUBLIC-UTILITY COMPANY

The advantages to a public-utility company from the operation of a plant for joint utility and industrial service are many. Through the operation of such a plant, the utility is often enabled to obtain customers for its services that could be obtained in no other manner. One of the greatest obstacles that an electric utility has to face occurs in cases of customers who require steam for their own process requirements and who can, without difficulty, generate part or all of their electrical requirements with that steam. It is a short step from the necessary operation of steam generation to the installation of equipment to generate the industrial's entire power requirement. The ability of the utility to supply the industrial's complete steam and power requirements permits such customers to be obtained. Once connected to the public-utility system, they can be retained easily. Frequently, as their load grows and their manufacturing processes are improved, there is a shifting in the relation between the industrial's steam and electrical power requirements, and this shifting is usually in the direction of an increase in the electric requirements without a compensating increase in the steam requirements. Such a shift in load permits the utility system to sell the industrial customer its increased electric requirements at profitable rates. In the case of the Louisiana Station, part of the reduction in steam output which took place in the first few years after the station was placed in operation was occasioned by a program of electrification in the oil refinery it served. Steam-driven auxiliaries, such as pumps and engines, were replaced by motor-driven ones, thereby decreasing the steam requirements and increasing the electric-power requirements.

The public-utility company operating a joint power plant also participates in the general economies which result from the larger size of station, which the addition of the industrial steam and power load makes possible. It also obtains additional quantities of by-product energy at low cost, thereby reducing its bus-bar costs. Frequently it is enabled to obtain by-product fuel at lower cost than would otherwise be possible.

However, one of the principal advantages to the utility is obtained indirectly from the stimulation which the operation of the joint plant gives to the business of its industrial customers and in turn to the community which it serves. Also, a plant of this kind, once embarked on its business of supplying large industrial customers with steam and power, is able to demonstrate an example of performance which will attract additional industrial customers. The steam and power business of these customers is an advantage in itself to the utility system, but the employment they bring to the community and the assistance they render to its upbuilding produce a degree of prosperity which indirectly benefits the utility system to a marked degree.

The Louisiana Station is a striking example of this. Its ability to furnish steam and electric power at reasonable rates, as demonstrated by its business connection with the oil refinery, was an important factor in causing its two large chemical customers to decide to construct their plants in Baton Rouge. These chemical plants have increased employment in Baton Rouge and have been the cause of adding hundreds of domestic customers to the lines of the public-utility system which is associated with the Louisiana Station.

On the other hand, the utility company, which undertakes to finance a power station whose design and capacity are largely influenced by the existing and prospective steam and electric requirements of industrial customers, must be sure of the financial stability of the industrial enterprises which it serves, and of the stability of the business in which they are engaged. Contracts may be drawn with great legal skill so as to be binding on the industrial customer, but, if the enterprise stops operations, the utility company will be left with part or all of its plant investment idle. The larger the block of industrial business that is served by the jointly operated plant, the more careful the public-utility company must be in assuring itself of the prospect of its continuation.

ADVANTAGES OF JOINT OPERATION TO THE COMMUNITY

The advantages of having both steam and electricity to offer for sale is of considerable benefit to the community as it provides the community through its Chamber of Commerce or other agencies two very essential commodities required by industries. Thus, the community is placed in a favorable position to attract new industries, which means increased population, larger pay rolls and increases in other purchasing powers. It also tends to lower electric rates to the home owners and business houses or small industries that are not users of steam, the lower rates being made possible through more efficient plant operation due to operation of larger units and the increased efficiency made possible by a substantial amount of electricity being produced by extracted steam.

CONDENSING OPERATION

One partial safeguard that can frequently be taken by the public-utility company against loss of industrial-steam business is to select a plant site and to make provision in the plant design so that the station can be converted to a condensing-type station if the process-steam load of the industrial plant is lost or severely curtailed. The selection of a site having access to an adequate supply of condensing water is one requisite. The arrangement of turbine-room equipment so that low-pressure condensing turbines can be added to generate power from the steam exhausted from the high-pressure units is another requirement. The Louisiana Station has been designed with both of these points in mind. While there has been no reduction in its steam output, the ability to generate energy with condensing operation has just proved of great advantage in planning the new extension which is now being completed.

Up to the present time the station operation has always produced a surplus of by-product electrical energy, which was available for the requirements of the public-utility system with which it is associated. However, the new contracts call for an increase in electrical load that will raise the ratio of energy to steam requirements to nearly 40 kwhr per thousand pounds of steam sold, or more than the plant generated in 1938. In addition, unavoidable fluctuations in steam and electric requirements will inevitably result in periods when this ratio will substantially exceed 40 kwhr. To provide for this condition, and also to provide energy for local distribution purposes, the two latest turbines to be installed have been equipped with surface condensers, permitting each of them to generate up to 18,750 kw of condensing power. These turbines can operate entirely as condensing units, or entirely as noncondensing units, or partly condensing and partly noncondensing. Future extensions to the station may either be similar to one of the two types of turbines now in the plant, or possibly of the straight condensing type of turbines.

In conclusion, the authors wish to point again to the operating record of the Louisiana Station for the past eight years, and to the new contracts which it has just begun to fulfill. With this record and the outlook for the future, the Louisiana Station stands as an example of the part which a public-utility company can play in developing the field of power-plant operation for joint utility and industrial service.

A Rational Approach to TIRE-TREAD DESIGN

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THE action of an automobile tire when moving over a road surface depends on three factors:[1] (1) Road surface, (2) vehicle design, and (3) tire-tread design. The first concerns the development of roads with surfaces on which a good grip by the tire is possible at all speeds and weather conditions and with suitable elevation at curves. The second concerns the automobile designer who must provide a vehicle which has satisfactory weight distribution, driving mechanism, and braking arrangements so that the degree of safety is as high as possible. The third factor, that is the tire design, is the one discussed in this paper.

The automobile tire has been in commercial production for more than 40 years.[2] Modifications for greater service, and to meet new demands arising from the improvement in automobiles and highways, have been introduced from time to time. The cord construction, obsoleting the older fabric type, revolutionized the tire in terms of long wear. The balloon tire with lower inflation pressures transformed the estimate of riding comfort provided by tires. Development of special heat-resisting carcass plies met the challenge of better roads and higher speeds by protecting against blowouts.

In these early developments in the tire to produce higher cushioning quality and greater life, with corresponding quietness, no great effort was made by tire manufacturers to improve the road-gripping qualities by developments in the tread design. However, considerable work has been done in recent years, to which reference will be made, by highway authorities, but it was not directed specifically toward the detail of tire design.

More recently, attention has been directed to the effectiveness of the tire as a protection against skidding. This hazard of driving has assumed greatly magnified proportions in recent years, due to greater congestion of vehicles on the highways, higher speeds, more regular use of cars in all kinds of weather, and the observable tendency on the part of the average driver to rely upon the greatly improved brakes of the up-to-date car. Therefore, an effective study of tire-tread design seems of prime significance.

In the research discussed by the author, which was carried out by the B. F. Goodrich Company over a period of two years, findings of considerable importance on the action of the tire tread on the road surface are made available. The entire project was undertaken to provide data so that an improved tire of a definite composition and treatment which would meet the conditions of modern traffic could be made available to the public. While this paper refers specifically to the basic research work, some observations on the actual tire, developed from these investigations, are given at the end of the paper. The tire development serves as tangible proof of the results of the research work.

GENERAL CONSIDERATIONS OF THE FRICTION OF DRY SURFACES

Frictional forces are called into play at the common boundary of two surfaces when one is made to slide or roll on the other. The friction is caused partly by the interlocking of the irregularities in the two surfaces and partly by direct cohesion between the molecules of the contacting surfaces. If the surfaces are rough the first cause will prevail and friction will be high, but if they are comparatively smooth friction will be low. This type of sliding friction is of two kinds: Friction of rest and friction of motion. With ordinary surfaces the friction of rest, i.e., the frictional force required to produce impending motion, is higher than the friction of motion, i.e., the frictional force required to maintain relative motion. The two resistances are generally referred to as the static and kinetic friction.

Rolling friction is the resistance observed where a surface of revolution is rolled upon another surface, plane or curved. It is also due partly to irregularity of the surfaces, which will cause irregular variation of the distance between the center of gravity of the rolling body and the horizontal plane of motion. This, together with the irregular distortion of the material at the point of contact, will cause a dissipation of energy, resulting in frictional resistance. On the other hand, cohesion between the contacting surfaces plays an important part in this resistance. Where the bodies in contact are hard and smooth the friction is very small, but it will depend on the character of the materials and upon the finish of the surfaces. The resistance to rolling friction is generally only a small fraction of that to sliding friction. Even Coulomb observed the rolling friction to be only 3 per cent of the resistance due to sliding.

TIRE ACTION ON DRY ROADS

When the action of a tire on the road is considered, rolling friction should be distinguished from sliding friction. However, pure rolling practically does not exist; it is always accompanied by a slight amount of sliding. If the rolling action greatly predominates, as in the case of a free-coasting vehicle, the frictional resistance is very small. But if, by the application of brakes, the tire be caused to slip, then the frictional forces developed due to slippage will be greatly increased. It should be noted that by intermediate braking various amounts of slippage can be introduced all the way from pure rolling to pure sliding.

The rolling resistance of a rubber tire on a dry and good concrete road is generally regarded as being in the neighborhood of 2 per cent, i.e.

$$F = \mu W = 0.02W$$

where F is the resistance to traction, lb; W is the load of the tires, lb; and μ is the coefficient of friction. Stated otherwise, the resistance to rolling is 40 lb per ton of load, a figure usually

[1] "Factors Affecting the Behavior of Rubber-Tyred Wheels on Road Surfaces," by J. A. Bradley and R. F. Allen, Proceedings of the Institution of Automobile Engineers, vol. 25, 1930–1931, pp. 63–92.

[2] "Tires and Their Places in Automotive Transportation," by K. D. Smith, Symposium on "Place of Materials in Automobile Roads and Rides," American Society for Testing Materials, Philadelphia, Pa., October, 1935.

accepted for design purposes.[3] Whether the considerations of Reynolds[4] are valid or not in the case of a rubber tire on a road, it is clear that when higher values of the coefficient of friction are observed, a certain degree of sliding must be present. The large increase in the coefficient of friction when brakes are applied to the wheel is due to this increase in sliding, and coefficients of friction as high as 0.8 or even 0.9 have been measured by a number of investigators.

From the foregoing facts, the action of a tire on a dry road can be visualized. Under normal operating conditions on level concrete road the frictional forces will be low. If braking effort be applied, the tire will commence to slip and the coefficient of friction μ will rapidly increase. Data are available which indicate that as a braking force is applied this will cause a slowing down of the rate of revolution corresponding to pure rolling or, in other words, a slipping of the wheel. Further increase of the braking force decreases still more the rate of revolution until the wheel becomes locked, introducing pure sliding. From measurements made by Bradley and Allen[1] on sidecar tests it was shown that when the slippage had been brought to about 20 to 25 per cent, the braking force was not far removed from the maximum obtainable and higher rates of slip did not change appreciably the value of this retarding force. This retarding force will be maintained more or less constant until the condition of 100 per cent slippage is reached when the wheel, becoming locked, passes into the stage of pure sliding with a decrease in μ. In the following, the maximum value which the statical coefficient can obtain is called the coefficient of impending skid μ_1 and the subsequent but smaller value obtained for the kinetic coefficient with 100 per cent slippage is called the coefficient of full skid μ_2.

Agg[5] carried out a series of investigations in which the wheels of the car were prevented from rotation by fastening them to the chassis frame and measured the magnitude of the coefficients existing when sliding started and also when the sliding was uniform. The tests were made on a sand-filled brick road in fair condition and with balloon tires inflated to 30 lb per sq in. for both dry and wet surfaces. The value found for the coefficient μ_1 of impending friction on a dry road is 0.86 while on a wet road it was found to be 0.61, where

$$\mu_1 = \frac{\text{Force to start sliding}}{\text{Normal pressure}}$$

The coefficient of friction for full skid μ_2 on a dry road was found to be 0.82, while on wet road it was found to be 0.56, where

$$\mu_2 = \frac{\text{Force for uniform sliding}}{\text{Normal pressure}}$$

These coefficients for dry surfaces more or less agree with the values obtained by Bradley and Allen.[1] The results also indicate that for tires with a worn tread, in which the area of contact between the tire and road was consequently large, this value seemed to rise with an increase in speed. Agg[5] further showed that as the tire pressure was increased there was considerable drop in the values of μ_1 and μ_2, as shown in Table 1. This increase due to decrease in inflation pressure can be explained on the grounds that the higher inflation pressures will produce smaller contact areas for the same load and hence lower values of μ. Further work done by Moyer[6] seemed to indicate these coefficients would, under certain conditions, increase with speed.

TABLE 1 VALUES OF COEFFICIENTS OF FRICTION

Inflation pressure in cord tires, lb per sq in.	Coefficients of friction			
	Dry road		Wet road	
	μ_1	μ_2	μ_1	μ_2
40	0.90	0.85	0.74	0.69
50	0.88	0.84	0.64	0.58
60	0.80	0.76	0.63	0.56

In general, the coefficients of friction between tires and dry roads are sufficiently high so that no skidding is liable to occur and if slippage is caused by emergency braking the frictional coefficients are high enough to wear off the tread rubber.

TIRE ACTION ON WET ROADS

The analysis of a tire on a wet road raises an entirely new set of problems because the water acts as a lubricant and provision must be made for its removal from underneath the tire if the higher values of frictional coefficients as pertain to dry surfaces are to be approached. We have already seen that with smooth or worn treads operating on dry roads the values of μ are high. With wet roads, however, such tires have no provision for getting rid of the water entrapped between the tire and the road. Consequently, it would be expected that a tire with a worn tread operating on a wet road would show a big decrease in the value of μ. Moyer found this to be true even though the contact area for the smooth treads was in some cases 50 per cent greater than the tires with new treads. A new tread gives a higher value of μ because the tread, if suitably designed, acts as a windshield wiper so as to wipe the water from the road surface. Moreover, the water if not eliminated by the wiping action of the leading tread edge is easily squeezed out by the pressure into the grooves of the tread. This drainage effect is as important as the wiping action of the tread. These characteristics are in general true for the higher operating speeds. From the conditions which surround this wiping action, it was thought that once a definite set of conditions was established between the tire tread and the road the best results would be obtainable from a tire with a tread design which offered a continuous surface of contact to the road thereby insuring that contact conditions once established would be more or less maintained.

TEST PROGRAM

Analysis of the foregoing points suggested that a tread with a continuous surface of contact between tire and road and one which would also provide an efficient wiping action would enable much higher coefficients of friction to be developed. On this basis, a series of tests of various simple tread designs

TABLE 2 BASIC TYPES OF TREADS ANALYZED AND THEIR EXPECTED PERFORMANCE

Tire tread, type of rib	Type of contact	Wiping action	Expected performance: Impending-skid coefficient, μ_1	Expected performance: Full-skid coefficient, μ_2
Circumferential	Continuous	Poor	High	Low
Transverse	Noncontinuous	Very good	Low	High
Angular	Continuous	Good	High	High

[3] "Road Vehicle Performance," by R. W. Collins, Association of Engineering and Shipbuilding Draughtsmen (London), 1935, Draughtsman Publishing Co., Ltd., London, England.

[4] "On Rolling Friction," by O. Reynolds, Philosophical Transactions of the Royal Society of London, vol. 166, 1876, p. 131. Also: "Papers on Mechanical and Physical Subjects," by O. Reynolds, University Press, Cambridge, England, 1900–1903.

[5] "Tractive Resistance of Automobiles and Coefficients of Friction of Pneumatic Tires," by T. R. Agg, Iowa Engineering Experiment Station, Iowa State College, Ames, Iowa, Bulletin No. 88, May 2, 1928.

[6] "Skidding Characteristics of Automobile Tires and Roadway Surfaces," by R. A. Moyer, Iowa Engineering Experiment Station, Iowa State College, Ames, Iowa, Bulletin No. 120, August 8, 1934.

FIG. 2 THE TEST EQUIPMENT

was begun, and each time the results were compared with the action of a smooth tire.

Approaching the problem from this standpoint, various basic types in tread design were first analyzed and graded, as shown in Table 2.

Since the coefficients of friction are high for dry-road conditions, the function of the tread is of real value when operating on wet roads in what might be termed the hazard zone. Consequently, the tests were all made on wet roads. Furthermore, since the coefficient of friction for side skidding has been shown by Bradley and Allen[1] to be substantially the same as for forward motion, only straight ahead skidding was investigated.

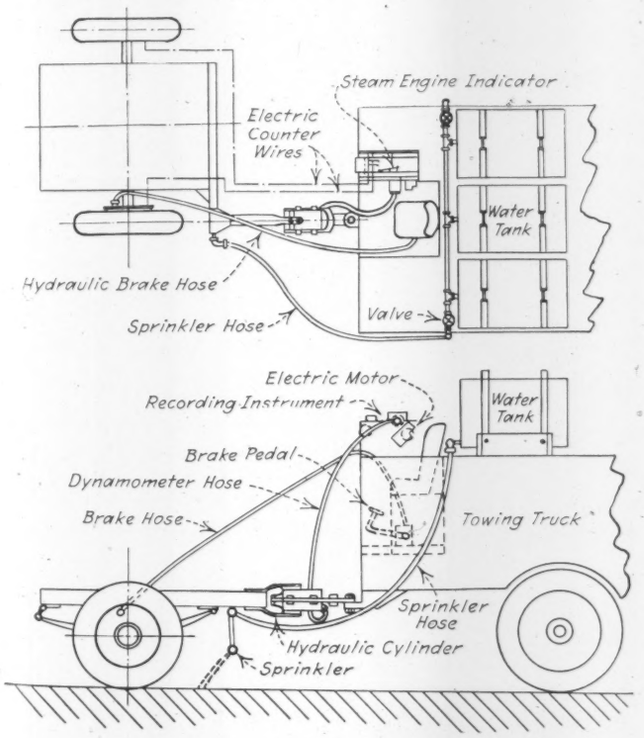


FIG. 1 ARRANGEMENT OF TEST APPARATUS

APPARATUS

In order to obtain the necessary test information on the skid resistance of different tread patterns, a special apparatus was built so that values of the coefficients of friction for impending- and full-skid conditions could be obtained. The test equipment is shown in Figs. 1 and 2.

This consisted of a two-wheel trailer towed by a truck. One wheel of the trailer was equipped with a hydraulic brake while the other ran free. The drawbar of the trailer was arranged in line with the wheel equipped with the brake and the drawbar pull was measured by means of a hydraulic dynamometer cylinder located in the drawbar so that the total pull exerted was transmitted to an oil column which communicated with a pressure-recording device. The revolutions of the braking wheel were recorded on a chart by means of two electric contacts on the wheel which controlled the supply of current to the pencil-operating mechanism; each half revolution was recorded. The road was wetted by means of a sprinkler mechanism in front of the braking wheel. A sample chart is shown in Fig. 3.

PRODUCTION OF TIRE TREADS

The tires used in this investigation were of the 600-16 four-ply type inflated to 30 lb per sq in. The load on the tire was 955 lb in all cases to simulate the pressure of a normally loaded car.

The tread designs were formed by cutting them on smooth-tread tires using the regroover shown in Fig. 4.

ROAD SURFACE

Previously published data indicated that a brick surface was as slippery as other types when wet and moreover was not subject to as much change as an asphalt surface due to rise in temperature. The test road selected therefore consisted of a monolithic repressed brick, grouted lightly with asphalt.

TEST PROCEDURE

In carrying out the tests, the tire inflation was checked and a level road selected. When a prearranged speed had been ob-

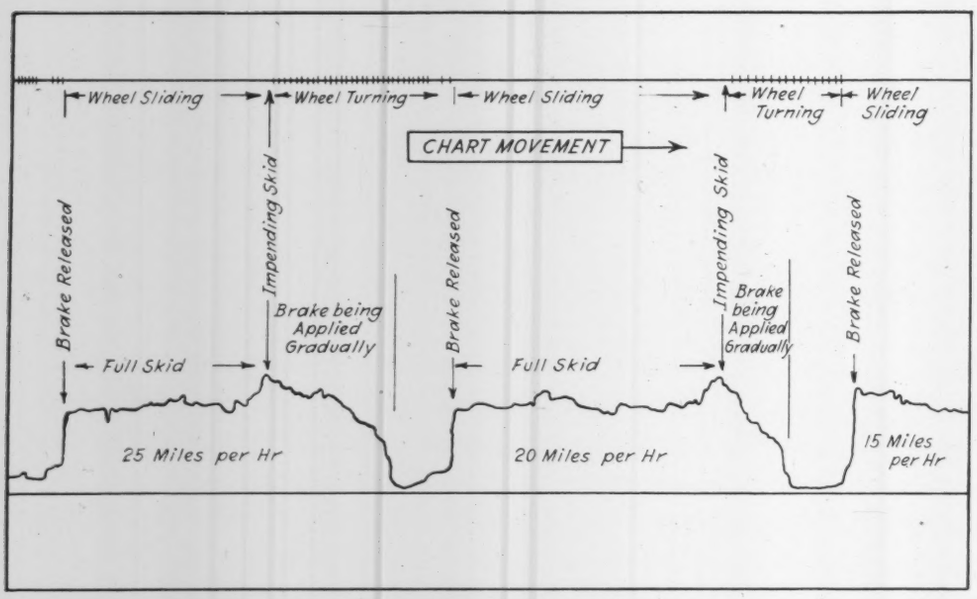


FIG. 3 CHART OF FRICTION EFFECTS

tained the truck driver signaled by the horn and the operator then opened the water valves, started the recorder chart, and began to apply gradually the brake to the trailer. This was continued until the wheel was sliding. The truck driver then increased the speed and a further series of tests was made. In order to minimize the effect of wind and grade, the tests were run in both directions and an average of both tests taken; the averages of the results obtained were considered as representative for the particular conditions. Tests were made at 5, 10, 15, 25, and 30 mph. This enabled the effect of velocity on the coefficients to be obtained.

Due to the method of drawing the trailer, some weight transfer took place. This weight transfer was calculated and deducted from the weight of the trailer wheel. For example, if W = weight on the trailer wheel = 955 lb, F = drawbar pull registered by the dynamometer, l = length of the draw bar from the center of the axle to the pivot of the attachment to the truck = 87.5 in. (in this case), h = height of the draw bar from the road = 24.5 in. (in this case), then the weight transfer $W_t = Fh/l$. Therefore, if the drawbar pull were 414 lb, then $W_t = (414 \times 24.5)/87.5 = 116$ lb, and the actual load on the trailer would be $W - W_t = 955 - 116 = 839$ lb. Hence, the coefficient of friction

$$\mu = F/(W - W_t) = 414/839 = 0.494$$

On the basis of the foregoing calculations a graphical relation between drawbar pull F and coefficient of friction μ was set up so that the value of μ could be read directly, given the value of F from a particular test. From the test data obtained, the coefficients of friction for the statical and impending-skid conditions were obtained as follows:

The statical or impending-skid coefficient

$$\mu_1 = \frac{\text{Force as skidding is impending}}{W - W_t}$$

and the kinetic or full-skid coefficient

$$\mu_2 = \frac{\text{Force while skidding}}{W - W_t}$$

In each case a smooth tire, that is, one without a tread, was run so as to provide a basis for comparison. In order to arrive at a comparative figure of merit for each tread, over the entire operating range, a coefficient-of-friction index was adopted. The index is the ratio of the mean value of the coefficient of friction, for a given tread at various speeds of sliding, to the mean value obtained for the smooth tread for full-skid conditions. It will be noted that this ratio is obtained by taking the ratio of the areas under the friction-velocity curves for the two tires. The friction index for the smooth tire under full-skid conditions was then taken as 100.

The friction index for impending skid is

$$F_1 = (A_{if}/A_S)\,100$$

where A_{if} is the area under the curve of impending friction versus velocity, and A_S is the area under the curve of full-skid friction versus velocity for smooth tires.

The friction index for full skid is

$$F_2 = (A_{sf}/A_S)100$$

where A_{sf} is the area under the curve of full-skid friction versus velocity, and A_S is the same as given previously.

TABLE 3 TEST RESULTS FROM TREADS WITH CIRCUMFERENTIAL RIBS

Test no.	Number of ribs	Width of rib, in.	Drainage grooves: No.	Drainage grooves: Width, in.	Drainage grooves: Depth, in.	Friction indexes: F_1	Friction indexes: F_2	Ratio of bar width to groove width
1	0[a]	0[a]	0[a]	0[a]	0[a]	118	100	...
2	4	0.87	3	0.20	0.25	160	124	4.3
3	6	0.51	5	0.20	0.25	158	128	2.5
4	8	0.44	7	0.08	0.23	203	140	5.5
5	12	0.26	11	0.08	0.23	225	148	3.3
6	16	0.18	15	0.08	0.23	220	156	2.3

[a] Smooth tread.

TABLE 4 TEST RESULTS FROM TREADS WITH TRANSVERSE RIBS

Test no.	Width of rib, in.	Drainage grooves: Width, in.	Drainage grooves: Depth, in.	Friction indexes: F_1	Friction indexes: F_2	Ratio of bar width to groove width
1	0[a]	0[a]	0[a]	118	100	...
7	1.00	0.08	0.20	182	160	12.5
8	0.75	0.08	0.18	182	160	9.4
9	0.48	0.08	0.18	186	165	6.0
10	0.20	0.08	0.18	168	148	2.5

[a] Smooth tread.

TABLE 5 EFFECT OF GROOVE WIDTH ON TRANSVERSE RIBS

Test no.	Width of rib, in.	Drainage grooves: Width, in.	Drainage grooves: Depth, in.	Friction indexes: F_1	Friction indexes: F_2	Ratio of bar width to groove width
1	0[a]	0[a]	0[a]	118	100	...
9	0.48	0.08	0.18	186	165	6.0
11	0.48	0.20	0.18	208	184	2.4
12	0.57	0.11	0.18	196	178	5.2

[a] Smooth tread.

TABLE 6 TEST RESULTS FROM TREADS WITH ANGULAR RIBS

Test no.	Angle of bar, deg	Width of bar, in.	Drainage grooves Width, in.	Drainage grooves Depth, in.	Friction indexes F_1	Friction indexes F_2	Ratio of bar width to groove width
1	0[a]	0[a]	0[a]	0[a]	118	100	...
23	30	0.50	0.11	0.15	177	133	4.5
25	45	0.50	0.11	0.15	196	154	4.5
27	60	0.50	0.11	0.15	195	162	4.5
12	90	0.57	0.11	0.18	196	178	5.2

[a] Smooth tread.

TABLE 7 EFFECT OF BAR WIDTH ON ANGULAR RIBS

Test no.	Angle of bar, deg	Width of bar, in.	Drainage grooves Width, in.	Drainage grooves Depth, in.	Friction indexes F_1	Friction indexes F_2	Ratio of bar width to groove width
1	0[a]	0[a]	0[a]	0[a]	118	100	...
46	45	0.25	0.11	0.25	210	167	2.3
42	45	0.35	0.11	0.25	222	177	3.2
25	45	0.50	0.11	0.25	196	154	4.5

[a] Smooth tread.

TABLE 8 EFFECT OF GROOVE DEPTH ON TREADS WITH ANGULAR RIBS

Test no.	Angle of bar, deg	Width of bar, in.	Drainage grooves Width, in.	Drainage grooves Depth, in.	Friction indexes F_1	Friction indexes F_2	Ratio of bar width to groove width
1	0[a]	0[a]	0[a]	0[a]	118	100	...
41	30	0.25	0.11	0.25	216	162	2.3
47	30	0.35	0.11	0.25	234	167	3.2
23	30	0.50	0.11	0.15	177	133	4.5

[a] Smooth tread.

TABLE 9 COMPARISON OF FRICTION INDEXES OF VARIOUS TREADS

Test no.	Type of tread	Ratio of bar width to groove width	Friction indexes F_1	Friction indexes F_2
1	Smooth	...	118	100
5	Circumferential	3.3	225	148
11	Transverse	2.4	208	184
14	Square blocks	4.5	189	163
42	Angular, 45 deg	3.2	222	177

TABLE 10 FRICTION INDEXES FOR BEST TYPES OF TIRE TREADS

Test no.	Type of tread	Ratio of bar width to groove width	Friction indexes F_1	Friction indexes F_2	Tire action	Drainage
1	Smooth	...	118	100	Continuous	None
5	Circumferential	3.5	225	148	Continuous	Poor
9	Transverse	6.0	186	165	Noncontinuous	Good
11	Transverse,	2.4	208	184	Noncontinuous	Very good
42	Angular, 45 deg	3.2	222	177	Continuous	Very good
47	Angular, 30 deg	3.2	234	167	Continuous	Very good

TABLE 11 COEFFICIENTS OF FRICTION OF VARIOUS TREADS AT DIFFERENT SPEEDS

Test no.	Type of tread	Width of rib, in.	Drainage grooves Width, in.	Drainage grooves Depth, in.	Coefficient of friction: μ_1 at the following speeds in mph: 5	15	20	30	Coefficient of friction: μ_2 at the following speeds in mph: 5	15	20	30
1	Smooth	0	0	0	0.49	0.39	0.35	0.28	0.43	0.32	0.29	0.26
3	Circumferential	0.51	0.20	0.25	0.58	0.52	0.50	0.42	0.52	0.42	0.39	0.36
27	Angular, 60 deg	0.50	0.11	0.15	0.75	0.62	0.60	0.55	0.70	0.52	0.46	0.39
46	Angular, 45 deg	0.25	0.11	0.25	0.77	0.65	0.62	0.55	0.68	0.54	0.48	0.44

Thus, by comparing all data with the smooth tire, which was run as a standard with each group of tests, the variables which were liable to occur due to weather conditions or road changes were eliminated. This method also took into account the variables which arose because of velocity conditions.

TEST RESULTS

The results given here in Tables 3 to 9, inclusive, cover the tests on the three main types of treads: Circumferential ribs, transverse ribs, and angular ribs. Test results are also given which show the effect of other variables on these basic types.

The results in Table 3 for tires with circumferential ribs indicate very clearly that the drainage effect of the grooves is important and as the width of the ribs or lands between the grooves is decreased the friction indexes increase. Since such a type of rib gives very poor wiping action, the squeezing out of the water is the predominant factor and the best results are obtained on the narrower type of rib.

On tires with transverse ribs, the contact area between the tread and road is continually changing. This noncontinuity of action may explain the lower values in Table 4 obtained for the impending skid conditions as compared with those obtained with circumferential ribs, while the very efficient wiping action which this type provides may be shown by the higher values obtained for the full-skid conditions once sliding has ensued. The results also indicate that as the width of the rib is decreased beyond a value of 0.48 in., due to the lack of adequate tangential stiffness, the frictional indexes for both impending and full skid also decrease. It is also important that adequate drainage be provided for water to run off sideways.

With a transverse type of rib very good drainage is obtained by a groove 0.20 in. wide and no advantage is gained by increasing the width beyond this value. The results given in Table 5 demonstrate the importance of having sufficient drainage area. The contact area in test no. 9 will be greater than that in test no. 11, but this is not sufficient to compensate for the effects of the increased drainage. Consequently, higher values of F_1 and F_2 are obtained for test no. 11.

With angular ribs the inclination of the rib, provided this be greater than 30 deg to the diametral plane, gives a good wiping action, characteristic of the transverse type; also, it gives a continuous-contact action as obtained with the circumferential type. As shown in Table 6, it results in high friction indexes for both impending-skid and full-skid conditions. In other words, the angular type has combined the advantages of the other two types. From consideration of the bending action on the rib it could be concluded that the minimum width for most efficient wiping in the case of the angular type will be less than for the transverse type. This is true since the minimum width for the 45-deg rib seems to be in the region of 0.35 in. as shown in Table 7 whereas it has already been shown that for the transverse type this width was approximately 0.5 in. The deepening of the groove from 0.15 to 0.25 in., as in Table 8, has further increased the impending-skid coefficients.

Certain other types of treads were tested and these consisted essentially of square blocks instead of continuous ribs. The results on treads consisting of square blocks 0.9 in. square indicated lower values than those obtained for the angular bar for both the impending- and full-skid conditions. These seem to be at variance with the results of the work being conducted by

the Department of Scientific and Industrial Research[7] (England). The values are given in Table 9, and are compared with the results which were obtained with the best types in the other series.

DISCUSSION

The results of this investigation indicate very clearly the advantages in having a continuous surface of contact between the tread and road at all times, since this gives the highest values for the impending-skid coefficients due to the steady state which is reached. This is true for the circumferential and angular-bar types. The transverse type offers very good wiping action which is most apparent when the action is continuous as in the full-skid condition, in which case the coefficients are high. The angular type, however, gives continuity of action and good wiping which results in the highest coefficients for both types of skidding. The data seem to indicate that optimum wiping action for both the angular and transverse types is obtained when the ratio of bar width to groove width falls between 2.5 and 3.5. This is true provided the depth of the groove is adequate and the width of the rib is sufficiently great to prevent undue deformation, thereby reducing the wiping efficacy. The tests also clearly indicate the importance of satisfactory drainage for the water. The friction indexes for the best of each type are tabulated in Table 10.

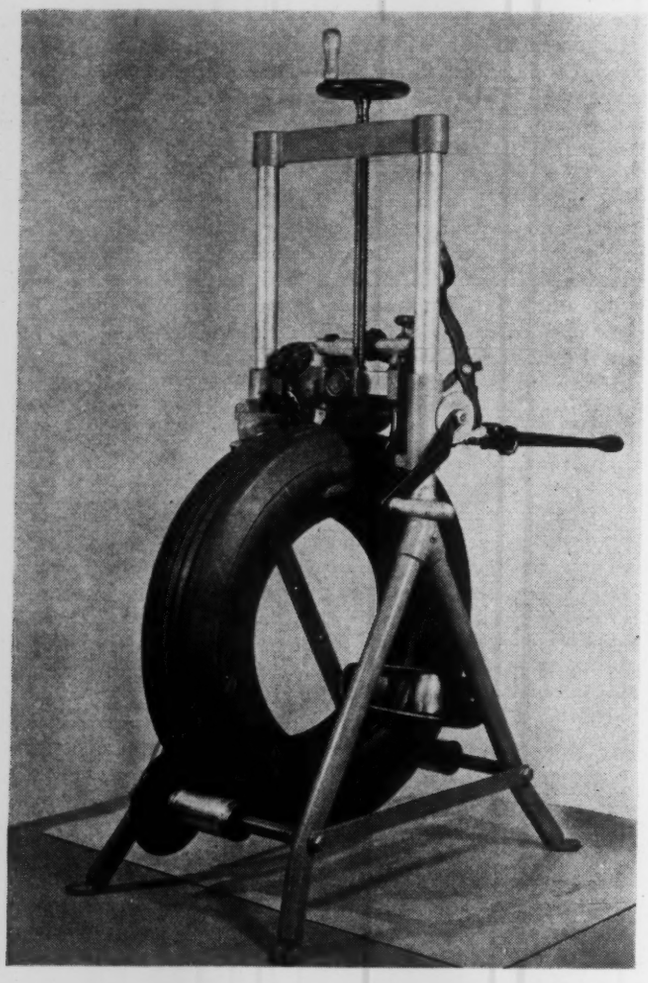


FIG. 4 REGROOVER USED IN CUTTING TREAD DESIGNS

In regard to the variation in individual tests it was stated earlier in the paper that each group of tests was preceded by tests on a smooth tire without tread design. An examination of the test results of such tires with smooth tread may be of interest as an indication of the general variation in other test results. Taking the initial test on such a smooth tire as the primary test, the maximum variation in the coefficients of friction obtained on subsequent smooth-tire tests, run at different periods, was from 10 to 15 per cent less than the primary results. This was true for both the static and kinetic coefficients. In the tests of the smooth tire in the group of tests associated with the angular-bar type of tread, this variation was somewhat greater, especially for the lower speeds of 5 and 10 mph. In this case the reduction in the coefficient of friction, both static and kinetic, was of the order of 20 to 30 per cent below the values obtained in the primary tests. At the higher speeds the maximum variation was reduced to within 10 to 15 per cent. These larger differences may be accounted for either by some sluggishness in the recording apparatus or by a change due to atmospheric conditions. Of course, any group of tests which showed divergence in the smooth-tire tests from the primary smooth-tire tests was subjected to correction but the foregoing experimental variations are being recorded. Moreover, the method which was adopted of using a friction index, based on the area of the friction-velocity curve, tended to minimize the effects of variation in individual readings.

STATIC AND KINETIC COEFFICIENTS OF FRICTION

Since the actual values of the coefficients of friction for both the statical condition (μ_1) and for the kinetic condition (μ_2) are of interest, these values for a few of the tests, with the tires having smooth, circumferential-rib, and angular-rib treads, are given in Table 11 for the various speed conditions. All these tests were run under the same weather conditions.

These data confirm the values given for the friction indexes in that high coefficients are obtained for the angular-bar types and that it is important to have adequate drainage area in relation to the rib width.

APPLICATION TO DESIGN

The results of this research were then applied to the design of tires which were subjected to tests under actual car-operating conditions. These subsequent investigations rendered necessary some modifications in the conclusions reached in the basic tests.

In order to obtain the benefits of the angular type, the sinusoidal curve bar—adopted primarily to eliminate the sharp angle "breaks" of the original tread pattern and so reduce hum to a minimum—was found to project still further the principle of continuity of tread design. Tests proved that the drainage action of the grooves was still preserved.

Following the completion of the investigation by the Goodrich engineers, the new tire tread was submitted to an independent testing organization and three months later after running the new tires over 95,000 miles side by side with other tires, they reported that: (1) The new tires exhibited better nonskid qualities than any other tire tested; and (2) none of the new tires failed while under test.

The present paper has been made possible by the collaboration of K. D. Smith and W. F. Billingsley of the B. F. Goodrich Company under whose supervision all of the experimental data were obtained.

[7] Third Annual Report of Road Research Board, 1938. Department of Scientific and Industrial Research. H. M. Stationery Office, London, England.

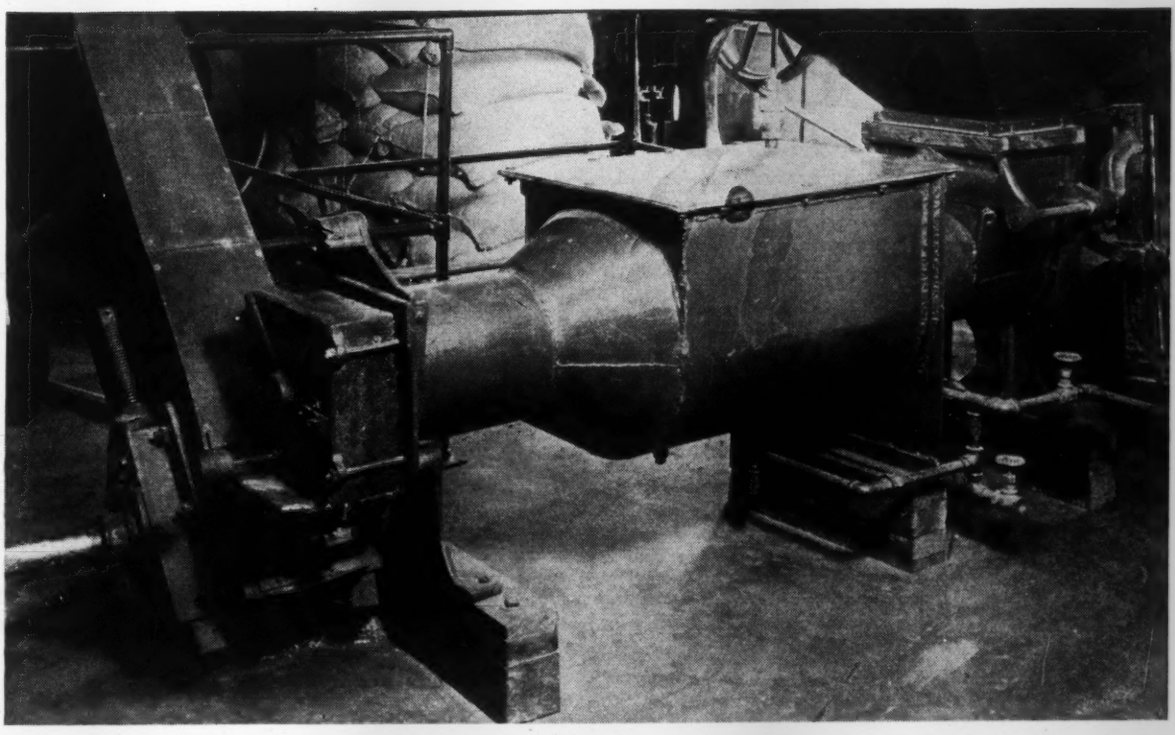


FIG. 1 A NEW LOW-PRESSURE MOISTURE CONDITIONER FOR COTTONSEED

COTTONSEED PROCESSING RESEARCH

By W. R. WOOLRICH

UNIVERSITY OF TEXAS, AUSTIN, TEXAS

EARLY IN 1929, a fund of $500 was offered to the author by an official representative of the Tri-States Cotton Seed Oil Mill Superintendents Association to start a research project in the mechanical processing of cottonseed at The University of Tennessee. The offer carried with it the stipulation that $200 of this fund must be used to promote a series of lectures with suitable preprints to be given to the association membership. As a postscript to the offer, the assertion was made that nothing important of a research nature had been accomplished in this field since Tompkins completed his work, "Cotton and Cotton Oil," in 1901.

There were two objections to acceptance of the undertaking. First, the organization making the offer was not made up of men financially involved as monetary investors in the industry. Second, three hundred dollars was a questionably small amount of money to start a research that was expected to make an impact upon an industry that some seasons reached a cash value of approximately one-quarter billion dollars.

A brief review indicated, however, that so little was known about the structure of the cottonseed, and so many traditional practices of the industry had no scientific foundation, that even $300 might produce some worth-while results if the research were closely directed. The offer was accepted for the Experiment Station of the University by the director, Dr. C. A. Perkins.

The first work was directed toward a micrographic study of the cottonseed cell throughout growth and during rolling, cooking, and expressing under widely varied conditions. It later proved that this early period of research was the most romantic of the several years of study. These photomicrographic plates were the foundation for certain early conclusions, as follows:

(1) That the age-old tradition of the industry in assuming that rolling broke down the cell structure was wrong. The cells were, for the most part, intact after rolling. Rolls, as operated in good mill practice, produce flakes of seven to eight thousandths of an inch in thickness and do not break down cell structures, since such cells are only about one thousandth of an inch in diameter and have a tough epidermis.

(2) That there was no great virtue in prolonging the cooking period over a period of many hours. The reason why practice had proved a long cooking period most desirable in using

Contributed by the Special Research Committee on Cottonseed Processing for presentation at the National Spring Meeting, New Orleans, La., Feb. 23–25, 1939, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

the conventional cookers was that the crushed seed was as good an insulator as good asbestos fiberboard, and the long cooking period was essential to compensate for ineffective cooking equipment.

After the first year of investigation, the Experiment Station of the University supplemented the second year's grant of the Tri-States Cotton Seed Oil Mill Superintendents Association by $1000. Preliminary investigation was started on new methods of transmitting the heat to the cottonseed and in more closely controlling the moisture content.

This study, carried on chiefly by Prof. E. L. Carpenter, now of Rhode Island State College, revealed that a cooking time that was only a fraction of that used in the conventional stack cooker was required, and further, that moisture control in the cooking operation was even more essential than the industry had presumed.

From the results obtained over this first two-year period, a definite request was made to The Engineering Foundation, through the Research Committee of The American Society of Mechanical Engineers, for a grant-in-aid from that Foundation. Included in the request for this grant-in-aid was the agreement to prepare a complete bibliography of cottonseed literature.

As is true with many other southern products, bibliographies related to them are very limited in American libraries. In the Engineering Societies Library, New York, N. Y., only nine indexed items were found on cottonseed processing. In the Library of Congress, 28 were available. In the John Crerar Library of Chicago, seven indexed related topics were given. Other technical libraries of America revealed a similar dearth of available literature on cottonseed processing.

The first contribution from The Engineering Foundation made possible the present complete bibliography compiled mostly by Robert York, now of Carnegie Institute of Technology. This bibliography covered all phases of cottonseed processing. It was printed in 1935 and contained more than 600 entries. Most of the reference material was acquired by, and is now available in, the Engineering Library of The University of Tennessee, Knoxville, Tenn.

To give the research study wider recognition under The Engineering Foundation grant-in-aid, a Special Research Committee on Cottonseed Processing was established by The American Society of Mechanical Engineers' Committee on Research. This paper is primarily a progress report and a brief history of the work accomplished to date under the sponsorship of this special research committee.

In 1934 supplementary assistance was given the project by the Tennessee Valley Authority under the Division of Agricultural Industries.

The Tennessee Valley Authority was interested in cottonseed because of the fertilizer value of the seed, and the cash value of cotton products in the agricultural program of the South.

The fertilizer value of cottonseed to the South is little understood by economists of other regions. Every ton of clean seed cotton picked contains approximately 1300 lb of cottonseed. The remaining 700 lb is cotton lint. Cotton lint for the most part contains no fertilizer constituents. It is made up of oxygen, hydrogen, and carbon dioxide captured from the air, water, and earth, and nature's supply of these products is almost unlimited.

But cottonseed is the richest of all of our native seed grains in phosphate, potash, and nitrogen. The fertilizer value of cottonseed, until the United States entered the fertilizer field in 1918, was seldom below $21 per ton. Each ton of cottonseed meal exported from a cotton-growing area represented, therefore, a heavy drain upon the fertility of the soils of the region. The expressed cottonseed oil contained but very minute quantities of fertilizer constituents.

The development of new processes of oil extraction that could be economically operated in rural centers would encourage a decentralized processing and result in keeping the cottonseed meal in the centers of production. Some expeller plants had proved the effectiveness of small-plant production in keeping cottonseed meal in the area where it had been grown.

By 1935, the essential laboratory work of the project had been completed. An exhaustive report was printed in book form[1] by the Engineering Experiment Station of The University of Tennessee together with the corrected bibliography on cottonseed-processing literature. After the publication of this work, it was considered essential that any further work should be on a pilot-plant scale where actual plant conditions could be duplicated.

A summary of the statements with regard to pressure cooking in that report is of historical interest. A selected extract of that report reads as follows:

> A series of experiments planned to determine the effect of pressure cooking on oil yield show that it should substantially increase oil yields as compared to the present atmospheric methods.
>
> This is apparently due to better heat distribution and to retention of cooking vapors in pressure cooking.
>
> The data also indicate an initial moisture of 12 per cent and a final moisture of about 8 to 9 per cent as optimum.
>
> The ideal cooking time for pressure cooking under laboratory conditions was twenty minutes. The oil yield dropped off rapidly when a longer cooking time was used.
>
> In these tests it was found that the optimum cooking temperature for pressure cooking with a jacket temperature of 259 F was 242 F.
>
> These experiments revealed that the mass of meats handled in the rotary cooker affected both the quantity and quality of oil yield. In a full cooker, the ratio of water in the meats to the total free space is relatively high. Under such conditions the air-vapor mixture reaches saturation without excessive drying of the meats.
>
> When only a small quantity of meats are used, the moisture may not be sufficient to saturate the air and thus there results excessive drying of the mass.
>
> Previous tests on atmospheric cooking showed the best oil yields with a temperature of 225 F. It is evident that the cooking conditions within a closed-cooker permit maintaining wet steam conditions at a higher temperature than is possible under atmospheric pressures. This wet steam condition prevents excessive drying out of the meats with the consequent hardening of the cell wall.

From the results published in this report of 1935 by the Tennessee Experiment Station, sufficient interest developed on the part of several groups to underwrite completely the development of a pilot plant at the station. Approximately fifteen thousand dollars was represented in the 1936–1937 program. R. B. Taylor, of the Tennessee Valley Authority and The University of Tennessee, took full charge of the pilot-plant development.

A pilot-plant pressure cooker was designed, constructed, and operated with seed delivered from different mills. During this season, the plant consisted of pressroom equipment only. This included the commercial crushing rolls, experimental pressure cooker, hydraulic system, cake former, and hydraulic press.

The hulled seed were delivered overnight upon order from a commercial mill at Rome, Ga., then rolled, processed, cooked, and expressed at the Knoxville pilot plant.

Many tons of cottonseed were cooked and processed with the experimental pressure cooker under these conditions. The results were very satisfactory. Cooking was carried forward

[1] "Mechanical Processing of Cottonseed," by W. R. Woolrich and E. L. Carpenter, Engineering Experiment Station, University of Tennessee Press, Knoxville, Tenn., 1935.

on a 15-to-17-min cycle with temperatures from 250 to 280 F and with steam pressures maintained within the cooker of 15 to 18 lb gage. The increased yield and better control of the product was very gratifying.

At the beginning of 1937–1938, it was considered essential that the other auxiliary mill equipment be added to the installed press units. Research funds and materials equal to those of 1936–1937 were made available by the several agencies that had become interested.

In addition to the hydraulic equipment, an experimental expeller was installed for parallel investigations in expeller extraction.

Especially was it considered advisable to process representative lots of cottonseed from all over the cotton belt to determine whether the pressure-cooking method had a universal application to American grown cottonseed.

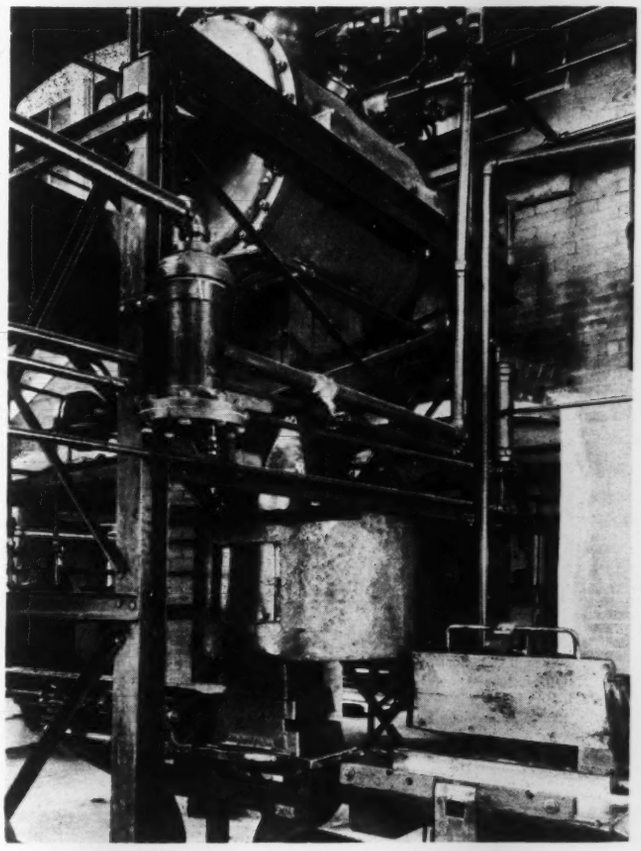


FIG. 2 EXPERIMENTAL PRESSURE COOKER

The results of the 1937–1938 tests demonstrated that the new equipment was universally applicable to seed of all qualities whether it came from the high-rainfall areas of the Southeast or the drier belt of the Southwest.

All of the seed were processed just as they came to the experimental mill. Notwithstanding the many variables, the pressure-cooking process seems to have made possible the processing of all seed in a similar fashion whether the moisture content was initially 6, 10, or 20 per cent, and whether the meats were milled to produce a meal of 40 per cent or 60 per cent protein. Relatively, there is a positive control in pressure-cooking practice not possible with atmospheric stack cookers.

The origin of seed received at the pilot plant in 1937–1938 was as follows:

Origin	Amount received
Huntsville, S. C.	1 car
Rome, Ga.	1 car
Cartersville, Ga.	1 car
Birmingham, Ala.	1 car
Decatur, Ala.	2 cars
Grenada, Miss.	1 car
Greenwood, Miss.	1 car
Leland, Miss.	5 tons
Wilson, Ark.	5 tons
Sweetwater, Texas	1 car
Memphis, Tenn.	1 car

The pilot plant was started on Dec. 20, 1937, and was operated more or less continuously until April 9, 1938. In general, the cooking procedure was to charge the meats at the cooker, bring them to a temperature of 270 F and a pressure of 15 to 17 lb gage in about fifteen minutes. The pressure was then lowered to atmospheric in one to three minutes, thus giving a total cooking time of 16 to 18 min.

Moisture in the form of steam was admitted into the cooker only when the initial moisture in the seed was not sufficient for proper cooking or when tests were being made to determine the effects of high moisture on the refining loss of the oil.

Some of the shipments received were very dry. It became evident that separation and rolling would be greatly improved if the delinted seed were conditioned prior to hulling, separating, and rolling. A small continuous moisture conditioner, Fig. 1, was therefore built and installed ahead of the huller.

The conditioner consisted of a short section of covered conveyer trough, 18 in. in diameter and 24 in. long. The feed and discharge sections consisted of a 10-in-diameter pipe within which were short sections of standard 9-in. double-flight screw conveyer. The feed screw extended from under the feed hopper to within 6 in. of the point of entrance to the treating chamber. The discharge screw extended from the point of exit from the treating chamber to within 2 in. of the discharge spout. Within the treating chamber were flights or pickers which keep the seed agitated and moved them along from the point of entrance to the discharge, where they were picked up by the discharge screw. A hinged and weighted door over the end of the discharge pipe kept the seed tightly packed in the discharge pipe. Steam was admitted at two points in the bottom of the treating chamber. Since the feed section and the discharge section run full of seed all of the time, a material seal was formed so that a slight pressure was maintained in the treating chamber. A variable-speed drive was provided, making it possible to vary the rate of feed over a fairly wide range. The volume of the chamber was such that when the machine was operated at a capacity of from 1 to $1^1/_2$ tons of delinted seed per hour, the seeds were subjected to the action of the steam for $1^1/_2$ to 2 minutes.

The results acquired by introducing this conditioner to overcome the mechanical difficulties in separating and rolling were of great interest. Not only was it possible to eliminate shattering in the huller and secure better hulling and separation, but the rolling was much more satisfactory and the chemical and physical characteristics of the oil and meal produced greatly improved.

MOISTURE CONTROL IN COOKING

To give positive control of moisture during the cooking process and in the resultant cake, adjustments were made of the

pressure in the cooker for each charge. Seed with more than 10 per cent moisture produced sufficient steam to give the required pressure in the cooker. When the moisture was excessive, the pressure excess was prevented by venting. This dried the meats in the cooker.

When dry meats were cooked, steam was added from a 15-lb pressure line after the steam gage on the cooker indicated that there was a lack of sufficient moisture in the meats being cooked.

Fig. 2 is from a photograph of the cooking and forming equipment of the pilot plant.

The method which gave the best result was as follows: The meats were charged in the cooker and heated to a temperature of 220 F as quickly as possible, which required from 5 to 7 min. At this point steam was admitted to the inside of the cooker until the pressure reached 15 lb gage, which required one minute. A pop valve in the exhaust line ahead of the exhaust valve was set at 17 lb gage. When the temperature of the meats reached about 265 F, the pressure had reached 17 lb, and as the temperature arose above that required to support the 17-lb pressure, excess moisture was vented through the pop valve. When the temperature of the meats reached 270 F, the pressure was exhausted, which required one minute. The total cooking time was from 17 to 18 min. The average resultant cake analysis for eight batches cooked in this manner was: moisture, 6.77; oil, 4.57; and ammonia, 9.35.

HYDRAULIC-PRESS PROCEDURE

The correct time allowed for pressing of the formed, cooked meal was experimentally determined. Thirty, forty-five, and sixty minutes were used in some of the early experiments. The commercial practice is to allow the pressure to build up slowly to about one eighth of the final press pressure and then to apply the full pressure.

In commercial operation oil begins to flow from the cake almost instantly, and, by far, the greater portion is removed before the higher pressures are applied. Too rapid application of pressure is claimed to produce such densities in the mass of meats as will prevent the free extraction of oil. More important, however, is the desirability of prolonging the life of the press cloth by slow application of pressure on the cloth and contained meal.

The result of the tests using the three different periods differed by less than 2 per cent. This indicated that, for properly milled and cooked meats, a pressing period of 30 min was commercially adequate.

The improvement in oil production as obtained in the pilot plant by pressure cooking and subsequent hydraulic expression has established the proof of pressure-cooking effectiveness and has confirmed the results obtained in the laboratory experiments of the previous years. Pressure cooking of cottonseed meats nets an increase in oil extraction of 10 to 15 lb of crude oil per ton of seed crushed. Further, the pilot plant has demonstrated conclusively that it has universal application to cottonseed of all classes and variations.

EXPELLERS AND PRESSURE COOKING

The sequence of operations in previous commercial expeller practice has been to crack the separated meats in an attrition mill, dry them to low percentages of 2 to 4 per cent, and then deliver them to the expeller conditioner, which is a stock jacketed trough in which the moisture is brought up to the required optimum for expeller operation.

Expeller oils have possessed characteristics different from hydraulic oils, and special treatment has been required in the refinery.

In the pilot plant the rolled, pressure-cooked cottonseed meats worked exceptionally well in the expeller. The oil produced was equal to that obtained by the hydraulic method and better than that produced by ordinary expeller methods.

A small insulated storage hopper was built over the expeller to provide some storage for the cooked meats, since the expeller operates continuously and the cooker is batch-operated.

RESULTS AND FUTURE PROGRAM OF RESEARCH

The several important improvements made in cottonseed processing are summarized by R. B. Taylor in a statement in preparation for his 1938 annual report to the A.S.M.E. Research Committee as follows:

We do not claim specifically that we have produced crude oil of a quality much superior to that possible in ordinary mill practice; however, several results of our research in this respect are outstanding, notably, a tendency for the indicated percentage of free fatty acids to decrease during the processing, particularly in cases where the indicated fatty acid is very high, as in damaged seed. We are disinclined to accept the results at their face value and feel that some discrepancy exists between free-fatty-acid determinations made with oils secured by solvent extraction of laboratory samples of seed and the oil produced by hydraulic-press expression after pressure cooking. We are now directing our efforts to determine the cause of the discrepancy in the free-fatty-acid content of the oil, as indicated by the laboratory, from seed samples and in the oil actually produced in milling. Our refining losses have generally been somewhat lower than normal mill experience, but we suspect that these lower refining losses are accomplished by the reduction in meal impurities in the oil. When the meats come out of our cooker, a noticeable difference in character is observed at the former. The meats are remarkably free of water balls, are apparently fluffy, and yet readily yield their oil as the oil can be observed exuding from the press cloth even in the former. Upon pressing to 1800 lb per sq in. in 30 min, the resultant cake does not stick tightly to the press cloths, since the latter may be easily removed without the exertion of a greater force than is possible with two fingers.

The meats in the press do not crawl, and there should be a considerable saving in the cost of press cloths. The refining losses are relatively low; the meal impurites in the oil have been reduced and do not become entrained in the oil during pressing.

Because of our favorable experience with press cloth, it has been suggested that it will be practicable now to employ materials such as mohair in place of the Chinese human hair commonly used in the manufacture of press cloth. This utilization of mohair, a domestic material, appears to be inviting and of economic importance to the industry because the Angora goat must consume large quantities of protein to produce the material and the protein might well be supplied by cottonseed meal. Chinese hair press cloth is becoming both scarce and high in price because of the unsettled conditions in the Orient.

As indicated previously, our efforts this year included investigations in respect to expeller processing of cottonseed. We are indebted to the V. D. Anderson Company of Cleveland, Ohio, for the loan of a relatively small size Super Duo Expeller. We may summarize the results obtained with this processing unit by stating that it is possible to eliminate much of the machinery ordinarily employed with expeller installations that is both expensive in point of investment and in operating costs; the oil produced contains appreciably less foots than when employing conventional procedure; and the quality of the oil is in all respects comparable to hydraulic-press oil. It is even probable that the expeller operates at reduced power consumption when processing pressure-cooked meats than when processing uncooked materials. Considering the small type of machine on which the experiments were conducted, it was not possible to accurately determine power consumption in a way that will permit an accurate estimate being made of the probable saving when the process is applied to the larger machines.

The several important improvements in processing may be summarized as follows:

First, by the proper operation of this equipment it is possible to accurately control the moisture in the meats to the end that the best results may be expected. The moisture control during cooking is dependent to only a limited extent on the human element.

Second, the cooking time is materially shortened and, by the use of high temperatures and internal pressure, a more complete breakdown of cell structure is obtained in the cooker, relieving the press of the func-

tion of breaking the cell structure and limiting its function to one of forcing the oil to flow.

Third, it is well known that processing organic materials in closed vessels in the presence of moisture promotes hydrolysis and by this process certain of the nondigestible fiber of the cottonseed kernel is hydrolized or reduced to sugar, hence improving the digestibility of the meal and imparting a greater palatibility to that product.

Fourth, crude cottonseed oil as produced in all common processes is contaminated with extraneous substances that must be removed by subsequent processing. The pressure-cooking process appears to fix a portion of these extraneous substances in the cake or meal in a manner that does not permit such substances to flow from the press with the oil. These substances are ether soluble, however, and are indicated as fat in the laboratory determinations on cake as an indication of oil residue.

It is proposed in this connection to extract quantities of the residue oil in the cake or meal to determine the actual quantity of recoverable oil present in the cake as apart from the phospholipins and other fatty substances.

The several improvements which we have considered important are under patent application by The University of Tennessee Engineering Experiment Station and the Tennessee Valley Authority, as their interest may appear. The application for process patent, as it now rests, is expressed by mathematical formulas and I think cannot easily be subverted. We propose to defend the patents when, as, and if issued, in order that the results of our investigations and whatever improvements we may make will be available to the entire cottonseed industry and cannot be acquired by one or two companies to the exclusion of all others.

It is necessary to know how to operate the cooker and other auxiliary equipment as instruments of the complete process, and we have worked out a plan whereby manufacturers of equipment may apply for permission and license to construct the equipment embodying the principles we have developed.

The Engineering Experiment Station will request the manufacturers to submit the design of the equipment which they propose to sell, and upon the approval of the design, the manufacturer may sell the equipment to the industry with certain additional conditions. The University undertakes to assist the manufacturer, and the plant purchasing the equipment, to make a success of the new-type operation and to assist in training the operators in the proper procedure, for a reasonable length of time. Any improvements developed by the machinery manufacturers must be assigned to The University of Tennessee or the Tennessee Valley Authority, as the case may be, to the end that these improvements, too, may be made available to the entire industry.

It is proposed that the manufacturers of the equipment pay a small royalty on proven types of equipment. The royalty payments will be turned back by The University of Tennessee into further research for the upbuilding of the industry.

The adaptation of the improved processing machinery and processes in commercial applications will require close supervision and study by the research engineers of the university for the early applications so that necessary adjustments in design and methods of control may be worked out to permit the adaptation of the machinery and processes to mill practice with the least possible disturbance in established operating routine. This extended research is particularly desirable as a demonstration that certain processes such as rolling and time of pressure application can be efficiently operated in commercial plants as the operations at the engineering laboratory. Efficient rolling and proper application of pressure at the hydraulic press permits a more efficient performance on the part of the pressure-cooking equipment.

In those applications of the improved equipment where such extended research may appear to be desirable, The University of Tennessee, in cooperation with the manufacturer, will undertake to test or demonstrate the new manufacturing equipment in mills willing to undertake such tests, in which case the manufacturer's royalty is abated in favor of the mill purchasing the equipment. In cases where royalty is abated the University receives in lieu thereof all the experimental data accumulated in the application of the new type of equipment to industrial practice and exclusive right to patent new processes or equipment evolved as a result of the extended research.

It is hoped that eventually royalty revenue will be sufficient to make the research self-sustaining, however, it is not anticipated that income from this source will be adequate to cover the cost of continued research in cottonseed processing for the next several years. The University now has under way several projects in cottonseed processing research that have either suggested themselves as a result of the earlier research or have been suggested by members of the industry.

Projects in cottonseed research now being investigated by the University embrace problems in chemical, as well as in mechanical engineering. In the field of chemical engineering and chemistry three projects are now under way that are supplemental to the research of a strictly mechanical-engineering nature. The projects are:

(*a*) Studies in oil extraction by solvent process over the mechanical processes. It is well known that the solvent process removes large quantities of soluble gums, waxes, phospholipins, etc., as impurities in the extracted oil.

(*b*) Studies in washing oil to remove impurities. It is well known that the shrinkage experienced in processing crude cottonseed oil to refined oil is not proportional to the impurities removed, and the free fatty acids neutralized. The loss of shrinkage due to impurities is normally three and one-half times as great as the per cent of extraneous substances present.

(*c*) Studies in processing cottonseed hulls or hull bran to a lignin residue of suitable quality to permit application in lignin plastic production or for use as filler in the manufacturing of other plastic formulations as phenol-furfural compounds and the processing of liquors recoverable from the digestion process in lignin production, for the recovery of furfural. The objective of this research is to permit the use of cottonseed hulls or hull bran in more remunerative applications than its present use as a feedstuff.

Research problems that are of strictly mechanical-engineering nature at the Engineering Laboratory are:

(*a*) Design and testing of equipment that will permit the economical and continuous washing of oil as produced, drying the oil after washing, separating the wash water from the extraneous materials washed out, and discharging the extraneous materials to the process line ahead of the cooker. A successful demonstration of the elements of the process was made last year and from the experience obtained it is planned to further develop and perfect a unit to accomplish the objectives enumerated.

(*b*) Redesign the hydraulic press commonly used in the industry to provide more drainage area that should permit a greater recovery of oil and more rapid operation of the press.

(*c*) Continue research in expeller processing with pressure-cooked meats to confirm results obtained last year and permit more extensive research in improved procedure to obtain greater oil recovery. When it is considered that the expeller is capable of exerting a pressure of 12 tons or more per square inch against approximately 1800 pounds per square inch in the hydraulic press, it should follow that substantially more oil will be recovered in the expeller processing. The experience to date, however, does not favor either method over the other in point of oil yield. Results in both types of mechanical processing are approximately equal.

(*d*) Research and design of equipment for decorticating cottonseed by exploding or bursting the hull by application of high-pressure steam and sudden release to atmosphere. The feasibility of this process was demonstrated in last-year's research.

(*e*) Design and experiment with equipment for processing cottonseed hulls or hull bran for plastic lignin and furfural. The project contemplates eliminating the need for a column still in the recovery of furfural.

The Special Research Committee on Cottonseed Processing is gratified that its humble heritage of an appropriation of $300 from the productive workers of the industry in 1929 was the inspiration for an ever-widening, ever-challenging investigation into this supporting industry of the South.

That original appropriation was the spark which ignited new research flames to reveal new possibilities far beyond the dreams of the donors. The unfolding of the research findings of the past eight years indicates that the decades to come can well expand their studies into further discoveries of new possibilities of the unknown cottonseed. What has been accomplished in these first eight years of endeavor gives us just cause to commend those who have most earnestly sought out the revelations already recorded in this research quest.

The YOUNG ENGINEER'S RESPONSIBILITY *to* INDUSTRY

By HOWARD LEE DAVIS

POLYTECHNIC INSTITUTE OF BROOKLYN

THE YOUNG ENGINEER has many responsibilities to industry. In this short talk I shall limit myself to but one of them. In that one the young engineer has much the same responsibility to industry as has the graduate of any other college course. What makes the position of the engineer unique is that he is so much better fitted *at the start* of his business career than are those with more general education.

Now, in order that no one may possibly gather from this that I believe all engineers are, upon graduation, superior business risks to graduates of all other types of education, let me state with emphasis that such is not my opinion. The wise employing industrialist selects from the available candidates the man who seemingly will develop further and be most productive for his concern. There are some starting positions in industry for which the new employee must have a background of education in statistics, economics, physics, chemistry, mathematics, specialized engineering, metallurgy, or some other of the many branches of study. For those positions the available number of candidates is limited, but the wise employer still regards education as *one* of the vital elements to be considered. He still seeks the best balanced man.

Then there are many jobs of a semitechnical and even a nontechnical nature which are open to technically trained men only. For a good many of these, any type of technical education is adequate. The mental training and skill in the use of the engineering method are most in demand. For a great many other occupations a technical education is preferred. Probably in most other jobs it is adequate at the start. For these, then, the engineer is educationally equipped to compete with the nontechnical graduate. Thus the number of occupations open to the engineer greatly exceeds those open to the graduates in arts and general science. This is rightfully so, from the standpoint of the nontechnical men, for it has been found that, in many semitechnical and nontechnical positions, the man without technical training is handicapped in competition with engineering graduates.

Why is this so? Largely because technical studies train a man toward exactness. He must not acquire an inspiration or a hunch and then strive to prove it. He is trained to gather, impartially, all the available data relating to his problem. He must analyze those data. He must secure the opinions of others and then apply his own experience and gray matter. Industry has found that when a man so trained presents his solution of a business problem to his boss, he usually is better able to convince the boss that he has adequately explored, and has not greatly overexplored, the field; also that his conclusions are sound and worthy of adoption.

It does not follow logically from this that all college men should study technical subjects. Probably many arts and science graduates would have failed to complete a course in engineering, just as many engineers would have "busted out" of college, had they elected arts courses.

That is one reason why I have been unable to become greatly excited about movements that start now and then "to secure, for average engineering graduates, financial recognition comparable to that achieved by the average of those who have taken the so-called more cultural courses." From years of college employment experience, during which I interviewed literally thousands of all types of college undergraduates and graduates, it has become evident to me that the percentage of business getters and leaders is greater in the nontechnical than in the technical schools. Fewer numbers of that type of men are attracted to the engineering courses. But when you find a vitally sparked leader with a sound technical background, in which he has implanted an understanding of men and general world affairs, then you have a man worth fighting to get and well worth special attention during his trying, first years in business. You guide him, you stimulate him, you reward and guard him, if you are a wise employer. There are so few technically trained men like that!

Now, while a number of engineers, highly gifted in some relatively narrow field, have attained distinction in individual achievement and financial rewards, technical graduates in general cannot expect equal financial recognition as long as they continue to be absorbed almost solely in their interesting technical problems. But it would be gross overstimulation to try to stir all technical graduates to achieve distinctive leadership. And, of course, there are not that many distinctive leadership positions in industry. That is not my aim. I have always agreed that "we are successful when we accomplish somewhere near the limit of our own abilities." The difficulty is, however, that many engineering graduates, who could achieve much more, make little effort to expand. But when engineers fail to do as much as they reasonably can to develop themselves, they cannot rightfully complain when they remain in their, more or less, routine jobs while others, often with more general, and sometimes no college, education, and with less technical knowledge and method, pass them in the race for greater responsibility and financial return.

My answer then to the question: "What is the young engineer's responsibility to industry?" is, that he should do all he reasonably can to develop himself, not only technically, but, broadly, culturally. Industry needs more such live-wire, technically trained men. Business is constantly becoming more and more complex. Human problems have been, and will continue to become, more and more vital. Government has assumed more and more influence over industrial affairs. We shall never go back all the way. Successful business leaders must understand and be influential in the problems of our country and the whole world, for their businesses are influenced by conditions in countries even where they do not operate.

E.C.P.D. (Engineers' Council for Professional Development), working with and through A.S.M.E. and the other engineering societies, is making a major effort to guide and assist young engineers who desire broad development. Learn of its efforts to help you. Then do all you reasonably can to help yourself. This is your responsibility not only to industry, but to yourself. It is up to you to maintain and to increase that advantage that your technical education gave you at the start of your business career.

An address delivered at the Annual Meeting, New York, N. Y., Dec. 5 to 9, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

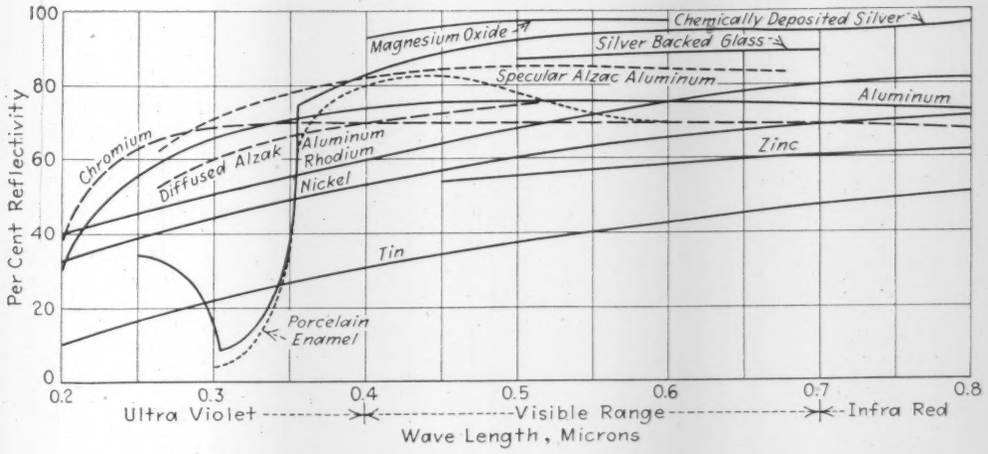


FIG. 1 APPROXIMATE VARIATIONS IN REFLECTIVITY OF VARIOUS POLISHED MATERIALS AT DIFFERENT WAVE LENGTHS
(Note: Alzak aluminum given ten-minute anodic treatment.)

MATERIALS *for* REFLECTING SURFACES

By WILLIAM IRBY

GENERAL ELECTRIC COMPANY, WEST LYNN, MASS.

ONE OF the most essential tools of the illuminating engineer is the simple reflecting surface, which may vary from a common and inexpensive material, such as glass, to rare and precious metals more costly than gold or platinum. New materials recently developed have removed former limitations in reflector design, resulting in an increased efficiency in the utilization of light from incandescent lamps.

It is the purpose of this paper to discuss some of the problems arising in the choice of materials and finishes for the actual reflecting surface of outdoor lighting units encountered in street, highway, floodlight, and searchlight installations. The amount of light produced by the unit as well as its distribution is dependent, in part, on the reflectivity and physical structure of this surface. Such factors as wind and weather resistance, chemical and electrochemical corrosion, solid and gaseous content and humidity of the air, and operating temperature are all factors which play a part in the selection of the proper material.

Well-lighted streets, public and private buildings, monuments, gasoline filling stations, railroad yards, football and baseball fields, swimming pools, and tennis courts are common. The lighting of highways is becoming daily more important. The problems of outdoor lighting are a challenge to the engineer and manufacturer to produce more efficient and less costly equipment with which to satisfy the needs of a fast-growing industry.

An ideal outdoor reflecting material should have the following characteristics: (1) a satisfactory initial coefficient of reflection,[1] (2) the ability to maintain its reflectivity in service, (3) ease and economy of fabrication, (4) sufficient rigidity in order to maintain its original shape and contour, (5) satisfactory heat resistance, and (6) reasonably hard surface that resists cleaning abrasives.

The materials in common use are glass, silvered glass, glazed porcelain, porcelain enamel, aluminum, stellite, and rhodium. The coefficient of reflection of these materials varies materially with the wave length of light. Fig. 1 gives approximate variations in coefficient of reflection with wave length for some of these materials. The surfaces having good reflection in the visible range are of major interest, since the light source in this work is generally the incandescent lamp.

PRISMATIC GLASS—SILVERED GLASS

Glass, in the form of globes, refractors, and door glasses, is widely used in street, highway, and floodlight work for controlling the distribution of light. This light control or regulation is accomplished by the rippled or prismatic construction of the glass itself as well as by the shape of the reflector unit. Dependent on its prismatic construction, the glass unit may be diffusing, refracting, or totally reflecting. The function of the prism is generally to bend the rays (refraction) so that they are distributed over the area desired; however, it is possible to construct the prisms so that the direction of the light is changed until it comes back in its original direction. In this case the prism acts as a reflector or totally reflecting prism.

Totally reflecting prismatic glass is used in making reflectors for interior lighting, but only to a very limited extent in exterior work. It is sometimes used in pendant and ornamental street lighting where an asymmetric distribution is required with shading on the house side.

The average coefficient of reflection of totally reflecting prismatic glass is 0.85 to 0.87. The material is heat- and weather-resistant but has the disadvantage of being fragile.

Probably one of the most efficient reflecting surfaces known is

[1] The coefficient of reflection is the ratio of light reflected from a surface to the total incident light.

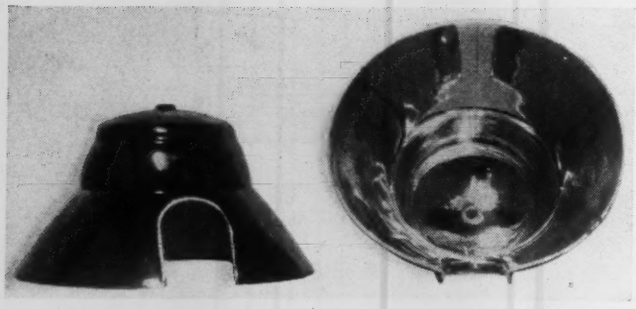


FIG. 2 SILVERED-GLASS FLOODLIGHT REFLECTORS WITH PORCELAIN-ENAMEL BACKING

FIG. 3 ORNAMENTAL STREET-LIGHTING UNIT WITH A GLAZED-PORCELAIN REFLECTOR

chemically deposited silver on glass. It has a reflection coefficient of 0.92 to 0.94. Second-surface silver or silver-backed glass has a reflection coefficient of 0.88. Silver-backed glass is an excellent reflecting material for street and floodlight work, provided the silver layer is properly protected from the heat and weather conditions encountered in service.

Silvered-glass reflectors have been used to a limited extent for years in street and searchlight fixtures and very widely used for floodlighting. It is the general practice in the trade to protect the silver layer by electroplating with copper or nickel, and covering it with an organic paint. This gives good protection to the silver for inside use at temperatures below 150 C, but in floodlights we are faced with outside corrosion conditions and temperatures up to 250 C. Silicate paints have been used as protective coatings for this type of reflector. The silicate finishes are highly heat resistant and are satisfactory for the temperatures required, but are not weather resistant. Recent tests by the author have shown that water vapor and gases occurring in the air are responsible to a large extent for the deterioration of the silver layer on reflectors protected with silicate-paint finishes.

A porcelain-enamel backing which is fired on the silver layer at 1050 F has recently been developed. This backing is highly resistant to heat, moisture, steam, salt spray, and outside weather conditions. This reflecting material is, in effect, a layer of silver which has been fired between two layers of glass. The coefficient of reflection of this type of reflector is 0.88. The material has many advantages over the silicate backing in both heat and weather resistance; however, it has the disadvantage of being fragile. Silvered glass protected with porcelain enamel is now being used for enclosed-type floodlight reflectors. Its use will, without doubt, be extended to street and highway lighting in cases where the reflector is protected from breakage. Fig. 2 shows silvered-glass reflectors having porcelain-enamel backing.

GLAZED PORCELAIN

Glazed porcelain is used in street-lighting work for sockets, receptacles, and insulators. It is also used to a limited extent for reflectors. A white opaque glaze is used on the reflecting surface, which has a coefficient of reflection of 0.75 to 0.80. In the design of lighting fixtures it is possible to combine the excellent high-voltage insulating properties of this material with

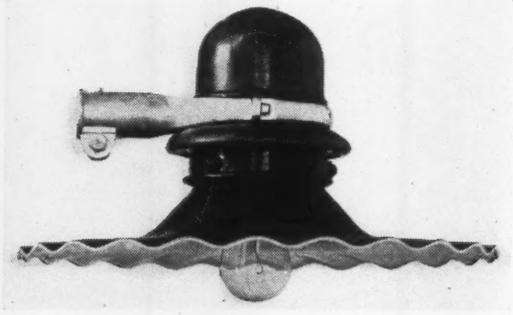
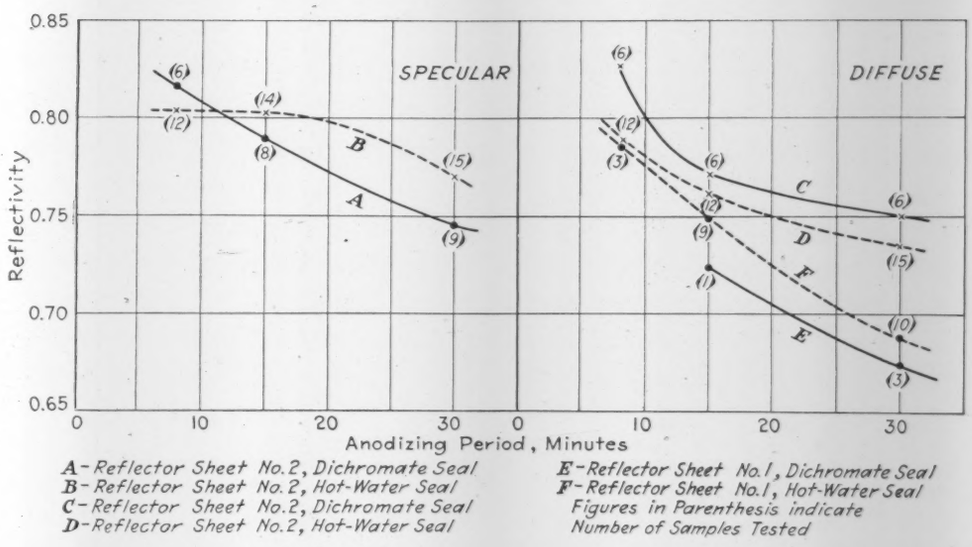


FIG. 4 STREET-LIGHTING UNIT WITH A PORCELAIN-ENAMELED STEEL REFLECTOR

FIG. 5 STREET-LIGHTING UNIT WITH A PORCELAIN-ENAMELED CAST-IRON REFLECTOR AND HOOD HOLDER



A-Reflector Sheet No.2, Dichromate Seal
B-Reflector Sheet No.2, Hot-Water Seal
C-Reflector Sheet No.2, Dichromate Seal
D-Reflector Sheet No.2, Hot-Water Seal
E-Reflector Sheet No.1, Dichromate Seal
F-Reflector Sheet No.1, Hot-Water Seal
Figures in Parenthesis indicate Number of Samples Tested

FIG. 7 REFLECTIVITY VS. TIME OF ANODIC TREATMENT OF SPECULAR AND DIFFUSED ALZAK-FINISHED ALUMINUM SAMPLES

its reflecting characteristics into a single unit having a pleasing appearance as well as low maintenance cost. Fig. 3 shows a street-lighting unit using glazed porcelain as the reflector.

PORCELAIN ENAMEL

Probably the most widely used finish for outdoor reflector work is porcelain enamel. This finish can be used on steel, cast iron, copper, silver, and other metals, but its use is largely confined to steel.

Reflector units are made from steel and cast iron and finished with porcelain enamel for use in street-lighting work. Porcelain-enameled steel units are widely used for floodlighting gasoline stations, baseball and football fields, tennis courts, and for sports in general.

Porcelain-enamel units have been replaced to some extent in this field by aluminum.

Figs. 4 and 5 show a porcelain-enameled steel radial-wave reflector, and a porcelain-enameled cast-iron reflector and hood.

White porcelain enamel as used for reflectors has a coefficient of reflection of 0.75 to 0.80, which is well maintained in outside usage. The reflector units are easily and inexpensively made and enameled, readily cleaned, and highly heat-resistant. The finish, if not chipped or broken, has an exceptionally long life in service.

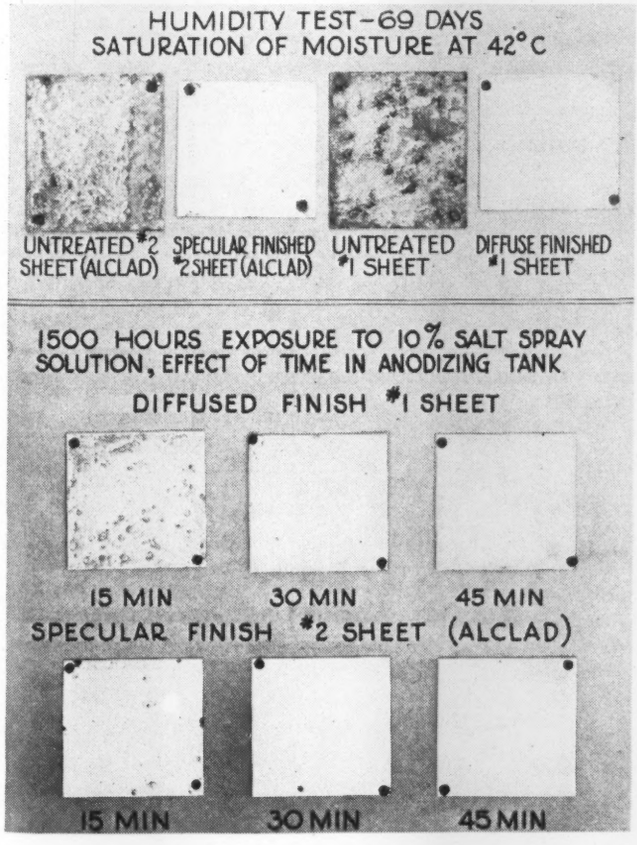


FIG. 6 ACCELERATED CORROSION TESTS ON ALZAK-FINISHED ALUMINUM SAMPLES

ALUMINUM

The metal aluminum has been used to a limited extent for outdoor reflectors for some years, but since the advent of the Alzak process[2] for treating aluminum, the use of this metal for outdoor reflectors has widened tremendously.

It will be noted from Fig. 1 that the coefficient of reflection of polished untreated aluminum is 0.76 at a wave length of 0.5 microns as compared to 0.92 for chemically deposited silver; but, at the wave length 0.305, the coefficient of reflection of aluminum is 0.66 and that of silver is approximately 0.08. Aluminum is one of the best reflecting metals over a wide range of the spectrum and is now being used in some cases in preference to silver for telescopic reflectors, due to its tremendous advantage when reflecting ultraviolet light.

The foregoing figures are for polished sheet aluminum which, of course, contains impurities. Pure aluminum has a much higher coefficient. Results have been obtained on aluminum coated on glass by the "vacuum-vapor process," which show its coefficient of reflection to be much higher.

The Alzak process is a method of finishing aluminum whereby the surface is rendered highly reflective as well as more permanent or corrosion resistant as a result of the treatment. There are, in general, two types of Alzak finishes used, the specular and diffused.

The specular finish results from the buffing and subsequent electrolytic "brightening" and anodic treatment of a special composite aluminum sheet while the diffused finish is produced by the etching of a standard aluminum-alloy sheet in a hot al-

[2] The patents on this process are controlled by the Aluminum Company of America.

FIG. 8 ALZAK-FINISHED ALUMINUM STREET REFLECTOR, WITH GLASS GLOBE REMOVED

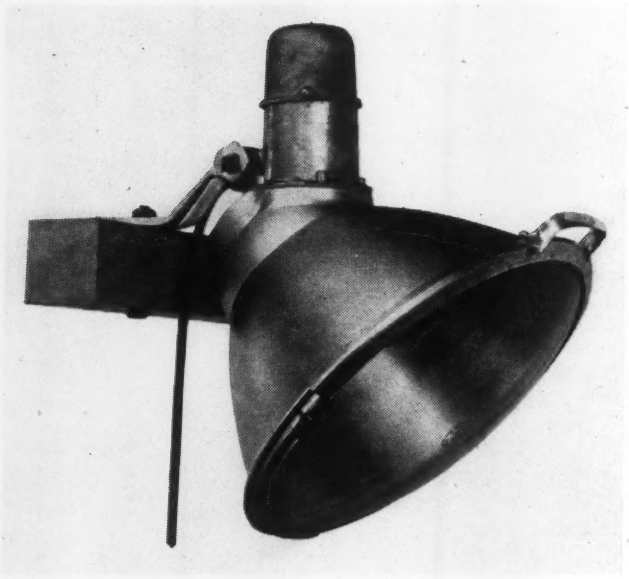


FIG. 9 FLOODLIGHT UNIT WITH AN ALZAK-FINISHED ALUMINUM REFLECTOR

kali solution which is followed by the brightening and anodizing operations. This treatment changes the surface of the aluminum to the oxide, which is a nonconductor of electric current. It also reduces the coefficient of reflection, the reduction being dependent to some extent on the time of anodic treatment as shown by the curves in Fig. 7.

The anodic treatment greatly increases the corrosion resistance of aluminum. This can be easily shown by accelerated corrosion tests. Fig. 6 shows the effect of warm humid air on untreated and Alzak-finished aluminum, as well as the effect of time of anodic treatment on resistance to salt spray.

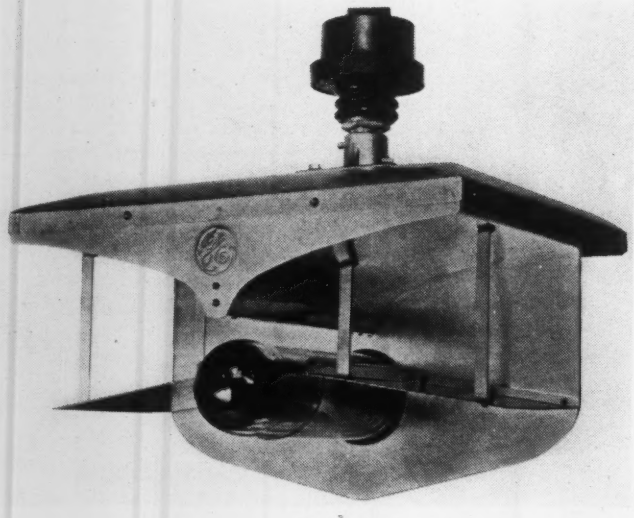


FIG. 10 SODIUM LUMINAIRE FOR STREET AND HIGHWAY LIGHTING, USING ALZAK-FINISHED ALUMINUM REFLECTING SURFACES

Figs. 8, 9, and 10 show reflector units made of Alzak-finished aluminum.

Alzak-finished aluminum is at present being used for street, highway, and floodlighting reflectors. The method of preparation of the surface, specular or diffused, as well as the time of anodic treatment and sealing process depend on the conditions under which the unit will be used.

The heat resistance of the anodic coating is good when it is thin, that is, below 0.0003 in. The heavier coatings tend to "craze" and crack when heated above 150 to 200 C, so that in floodlight reflectors the time of anodic treatment is generally 15 minutes or less. Fig. 11 shows the relation of time of anodic treatment to thickness and breakdown voltage of film.

Since the reflectivity is decreased and the corrosion resistance increased by prolonged anodic treatment, the time of treatment in some cases depends on whether the unit is enclosed with glass as in Fig. 9 or open as in Fig. 10.

Since only low temperatures are involved, it is good practice to give the open units a longer anodic treatment in order to insure good corrosion resistance. The open units are sometimes given the so-called "dichromate" sealing process, which consists of treating the unit in a hot dilute water solution of potassium dichromate. This treatment reduces the reflectivity (less than 2 per cent), but it also further increases the weather resistance.

Alzak-treated aluminum, although much more weather resistant than the unanodized metal, tends to corrode or pit on long exposure. This is particularly true of the diffused finish in open-type reflectors. This tendency can be materially decreased by periodic cleaning of the reflecting surface.

STELLITE

The group of alloys known as the stellites is made up of the metals cobalt, chromium, tungsten, iron, and sometimes molybdenum and carbon. One of these alloys is made in sheet form and can be polished and ground to precision dimensions for use in searchlight reflectors.

The material is highly heat resistant and withstands the heat generated by the high-current arcs commonly used in searchlights. The coefficient of reflection of specular-finished stellite is 0.62 to 0.64, which is maintained over long periods of time.

RHODIUM PLATE

Rhodium is a "noble" metal of the platinum group, having a beautiful luster and resembling silver in color. Its coefficient of reflection is 0.70 to 0.72. The interesting property of this material for reflector work is that it is highly resistant to heat,

oxidation, acids, and alkalies. It also maintains its luster for long periods of time. It has the disadvantage of being very expensive (present price is $115 to $130 per ounce), so that when electroplated on copper or copper-nickel surfaces, a very thin layer or "flash" is generally given in the order of 0.000005 in., due to the cost of metal involved. This thickness produces on a square foot of surface an intrinsic value of rhodium metal of approximately $0.25.

Rhodium when plated over nickel or copper-nickel has the disadvantage of all electroplated metals in that it is quite difficult to obtain a uniform surface which adheres well and is free from blisters and pinholes. If one can afford to plate a reasonably heavy rhodium plate of 0.00002 in. in thickness, good weathering results are obtained.

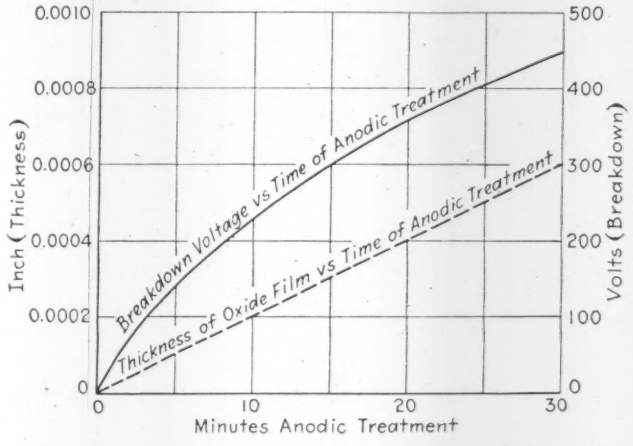


FIG. 11 RELATION OF TIME OF ANODIC TREATMENT TO THICKNESS AND BREAKDOWN VOLTAGE OF FILM

(The breakdown voltage was taken through the anodic film on both sides of the sample. The time was measured under standard conditions of current density and temperature.)

It has been found that commercially rhodium-plated brass and copper reflectors do not have the proper thickness of rhodium to stand up satisfactorily for street- and highway-lighting work.

Rhodium plate due to its heat and tarnish resistance has been found very satisfactory for searchlights. Methods have been developed in the trade whereby a glass blank of acceptable accuracy is plated with copper or other metals to the thickness required, after which the metal form is separated from the glass and its reflecting surface plated with rhodium, giving an accurate and efficient searchlight reflector.

TESTING REFLECTOR MATERIALS AND FINISHES

Before being sure that a material or finish is satisfactory for outdoor use, it must stand the test of time under actual conditions of operation. Tests are made of samples and units on the roof of the laboratory or plant, as well as in various parts of the country, so as to check the resistance of the material in rural, industrial, and marine atmospheres. This type of test, although sure, is quite slow, so that in development work accelerated tests are used.

The most satisfactory accelerated tests are probably the heat or oven test and those employing the steam chest and salt spray. It is very important in any accelerated test that no electrochemical action be set up between the sample tested and some other material. The test containers should be made of noncorrosive insulating materials. Slate is generally used for the salt-spray container and porcelain-enameled steel has been found satisfactory for the steam chest.

The heat or oven test consists of a prolonged exposure of samples to the heat of an electric oven at a temperature somewhat above normal operation in service. Floodlight reflectors are generally tested at 350 C. In the salt spray the samples are continually exposed to a spray or fog made by atomizing a 10 to 20 per cent sodium-chloride solution with compressed air at room temperature. In the steam chest, test samples are exposed to condensing steam at approximately 100 C. On some metallic materials the condensing steam has a more accelerated corrosion action than the salt spray. The breakdown-voltage method has been found helpful for testing the thickness of anodic coatings on aluminum, thereby giving information helpful in estimating the life of reflectors in service.

CONCLUSION

Materials and finishes for exterior reflectors used in street, highway, floodlight, and searchlight work have been discussed from the point of view of economy, reflection efficiency, and life in service. The utility and properties of prismatic glass, silvered glass, glazed porcelain, porcelain enamel, aluminum, stellite, and rhodium have been described. An improved silvered-glass floodlight reflector has been developed wherein the silvered surface is covered with porcelain enamel, making the reflector unit highly heat- and weather-resistant.

Air Conditioning

INTEREST in physiology and air conditioning, aroused by Dr. Haggard's Thurston Lecture, published in last month's issue of MECHANICAL ENGINEERING, is further stimulated by a report of the American Society of Heating and Ventilating Engineers which deals with the research work of another Yale scientist, Dr. C-E. A. Winslow, and relates to the physiological response of the human body to controlled conditions of atmospheric environment.

This research, says the report, deals with the most fundamental of all studies in the air-conditioning field. Through it is hoped to find how air conditioning may be used in the treatment of disease and its application to hospitals for improving conditions in the operating room and recovery ward. Studies undertaken at Magee Hospital in cooperation with the School of Medicine of the University of Pittsburgh, show that humidities in operating rooms must be kept between 55 and 60 per cent to obviate the danger from explosion of gases used in anesthesia. Research is being continued covering air conditioning in the treatment of diseases such as gonorrhea, syphilis, and allergic disturbances which are all closely associated with air-conditioning research.

During 1938 the scope of the work was extended to more intensive studies of air-borne bacteria and methods for their elimination. Both mechanical and electrical filtering and the use of ultraviolet rays have been utilized. Improvement of methods of air filtering to remove hazardous dusts and fumes and the ordinary dirt and smoke found in the atmosphere were also given special attention.

The report also stated that it had been by another research that the range of temperature necessary to provide optimum comfort to the public in summer air conditioning in any part of the country lies between 75 and 80 F, with relative humidities from 30 to 70 per cent. As a result of studies of critical temperatures in industrial plants the report says that under conditions calling for light labor, a maximum temperature of 96 F with a relative humidity of 75 per cent indicates dangerous ground.

These studies of industrial air conditioning it is said are expected to form the basis of more uniform codes for the guidance of employers, code authorities, and labor groups seeking to achieve increased efficiency without sacrificing the health and well-being of the worker.

BOILER-WATER TREATMENT

Discussion of Paper by F. G. Straub and T. A. Bradbury

IN THE May, 1938, issue of MECHANICAL ENGINEERING, F. G. Straub and T. A. Bradbury of the chemical engineering department of the University of Illinois, Urbana, Ill., contributed a paper, read at the A.S.M.E. Semi-Annual Meeting at St. Louis, Mo., on June 21, 1938, entitled "Boiler-Water Treatment, New Methods for Preventing Embrittlement." In this paper the authors described an apparatus for determining the embrittling effect of boiler water on steels and gave the method of procedure in running tests. Results of tests in different pressure classifications were given in tables together with the chemical analyses of the waters. The conclusion was reached that for steam pressures between 500 and 1400 lb per sq in., embrittlement is not prevented by the maintenance of the recommended A.S.M.E. ratios for boiler water. The discussion stimulated by the reading of the paper follows:

E. B. POWELL URGES STILL BETTER FABRICATION AS A PREVENTIVE

E. B. Powell[1] wrote: A serious deficiency of embrittlement research has been the failure of the test apparatus to simulate with assured definiteness the conditions met in the commercial boiler where embrittlement has occurred. The authors appear to have taken a long step toward avoiding this deficiency in reproducing, in a somewhat enlarged size, our normal concept of the typical capillary space and securing controllable results. In the absence of an adequately comprehensive theory of embrittlement and in the present seeming conflict of ideas on the chemical actions involved, apparatus in which the boiler water of an individual plant could be tested for embrittling tendencies and appropriate correctives determined if needed, would meet the situation rather happily.

The simplicity of the authors' test unit appeals strongly. However, the findings which they have secured are in striking departure from previously published data. The vital importance of the problem would seem to warrant an exceedingly careful examination of other related research and of instances of commercially encountered embrittlement, in so far as available evidence may permit, and also close critical analysis of the present test unit. As a step in the last-mentioned direction, critical thought on the paper prompts the following: As the authors point out, "the concentration taking place in the test container may bring about entirely different results from when the boiler water concentrates in the capillary areas of the boiler," and it would seem important that conditions making for differences of this kind be clearly understood and evaluated.

1 The test unit seems designed with great care to give uniform temperature conditions in the specimen. At the same time, it would be of interest to know the actual temperature rise in the lower part of the specimen, of reduced diameter in the vicinity of the typical fracture, in relation to the temperature indicated by the thermocouples shown in Fig. 1.

2 The filler used in forming the capillary space within the specimen is described as oxidized prior to use. The presence of metals of distinctly different surface condition in contact with a fairly strong electrolyte suggests the possibility that the electromotive force promoted by such difference in surface condition might be an important factor in the corrosion and embrittling effects observed. Possibly this is actually a factor of significance in the typical space of the embrittled commercial boiler.

3 Application of stress after attainment of full temperature in the metal and solution under test, while doubtless in some degree characteristic of locomotive-boiler operation, would seem highly unusual in the stationary steam-generating unit.

Turning to the chemical treatments described: The authors suggest that chemicals which combine with silica in such manner that silica present in the boiler water will no longer activate the caustic soda should aid in preventing embrittlement. This would seem a reasonable assumption, and would encourage a further assumption, that many common constituents of water, such as magnesium and calcium as well as aluminum and iron, might function in like manner. It would be of interest to learn whether or not the authors have found iron to exert an influence similar to that which they report for aluminum.

While it may be that, in existing 1200- to 1400-lb boilers, the maintenance of the R_2O_3-SiO_2 ratio found to be inhibitive by the authors would involve no special hardship, more recent projects call for use of high proportions of make-up of chemically treated water for high rates of steam generation at pressures of 1200 lb and higher. To be sure, silica in natural waters can be removed to relatively low value and, in all probability, some degree of silica removal will be undertaken in the majority of high-make-up, high-pressure plants. In general, however, the expense of the treatment increases rapidly as the concentration of silica in the make-up water is lowered under 2 or 3 ppm. The writer agrees with the authors emphatically that there should be no attempt at indiscriminate increase in R_2O_3 content of the boiler water, but that at least the seriousness of the hazard of analcite-scale formation, with the particular water and operating conditions, should first be determined.

A point on which all of our embrittlement research seems to be in agreement, and which gains much support from experience with the commercial boiler, is the importance of a highly stressed condition in the metal as a factor in causing embrittlement. Apparently, not only must the chemical conditions of the water be favorable to embrittlement but the metal in contact with this water must be subject to extremely high stress if embrittlement is to take place. The authors' conclusions suggest that those boilers of the 1200- to 1400-lb class in which the chemical conditions which they have found inhibitive do not obtain in the boiler water may owe their immunity from embrittlement to the stress relieving of the drums and a generally higher standard of workmanship employed in their fabrication throughout. The occasion seems opportune for a plea to the boiler manufacturers so to develop their methods of tube expanding as to give definite assurance of uniform freedom from possibility of capillary space or of stress sufficient to encourage embrittlement; that, having attained this accuracy of method, they also devise inspection procedure which will afford clear evidence of the joint condition obtaining in the commercial boiler as it will be then fabricated.

J. B. ROMER PRESENTS SERVICE RECORDS OF CRACKING

J. B. Romer[2] said: Before discussing the paper, I would like to congratulate the authors on their ingenuity in developing the test equipment which they have described, as well as their

[1] Consulting Engineer, Stone & Webster Engineering Corporation, Boston, Mass. Mem. A.S.M.E.

[2] Babcock & Wilcox Company, Barberton, Ohio.

carefully thought out research program. This new research tool will permit a thorough study of the action of many compounds which may be present in or can be added to boiler waters.

The test data presented cover a wide range of conditions and indicate that boiler-metal cracking, or caustic embrittlement as it is sometimes termed, can be inhibited by the proper selection of inhibiting agents.

Boiler-metal cracking has been a problem for many years and has been studied from many angles. Many of the early laboratory investigations were conducted in glass vessels with strong caustic solutions and hence any effect that silica may have had was entirely obscured. Many of the early investigators felt that atomic hydrogen played a part and they supplied the necessary atomic hydrogen by the application of an external electromotive force. In other experiments, sealed steel bombs were placed within the drums of operating boilers and certain experimental boilers were built and operated. The available literature was studied and the workers were constantly in touch with field experiences, all in an effort to obtain a rational explanation of this type of underwater cracking. The valuable data and experiences, thus collected, led to the formulation of the A.S.M.E. ratio for the prevention of embrittlement.

As far as the speaker is aware, the first research wherein the temperature, pressure, and stress were regulated and controllable over wide ranges, was that reported by Messrs. Parr and Straub in the University of Illinois bulletins.

In this work they used a test bomb which had been developed for the specific research, and which has since been described many times. Their studies with this equipment yielded valuable data and focused the attention of many workers on the problem.

Our organization has always been interested in this specific problem and has had an active part in the studies which led to the adoption of the present-day ratios by the A.S.M.E. Subcommittee on the Care of Power Boilers in Service.

The maintaining of this ratio has saved boiler operators many thousands of dollars; of this, there is no question.

In the last ten to fifteen years, boiler construction has materially changed. Such riveted construction, as has been fabricated, has been inside-caulked; welded construction has eliminated the butt-strap and other types of seams which were the locations wherein most of this type of cracking developed.

Operating pressures today are much higher than they were when the ratios were first adopted.

These conditions may require a new study to determine the utility of existing inhibiting materials and whether or not more beneficial materials are available for this purpose.

The test unit, described by the authors, has a feature which ties it in with past boiler experiences to a greater degree than any previous test equipment. This feature is the small annulus, or capillary space between the test specimen and the filler bar, and the even smaller capillary space at the top of this filler. Although the authors use boiler waters or solutions of comparable concentrations, they are able to concentrate these solutions in this capillary space in a manner distinctly analogous to the action within the seams of a boiler. This is a feature never heretofore obtained simultaneously with the control of temperature and pressure.

Fig. 7 of the paper shows the influence of sodium chloride and sodium sulphate on cracking at 250 lb absolute, or 450 F. In order to bring out certain points, this figure has been reproduced and is shown in Fig. 1. It will be noted that, with three exceptions, the cracking occurred at or to the left of the ordinate representing the A.S.M.E. ratio of 3.0. This is the minimum ratio recommended by the code for this pressure. It will also be noted that when the water tested had a low sulphate

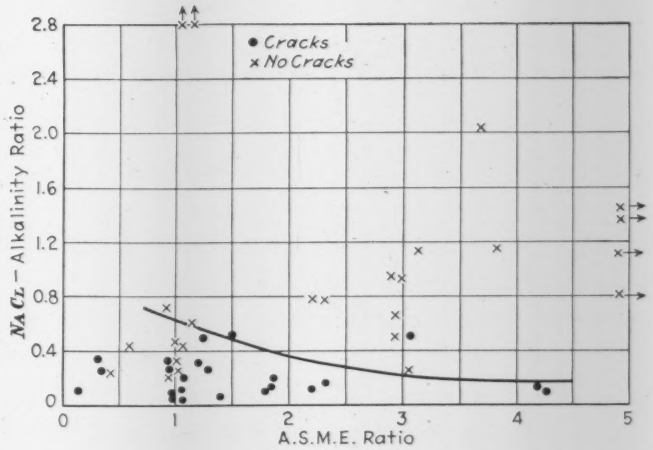


FIG. 1 INFLUENCE OF NACL AND NA_2SO_4 ON CRACKING AT 400 F, 250 LB ABS

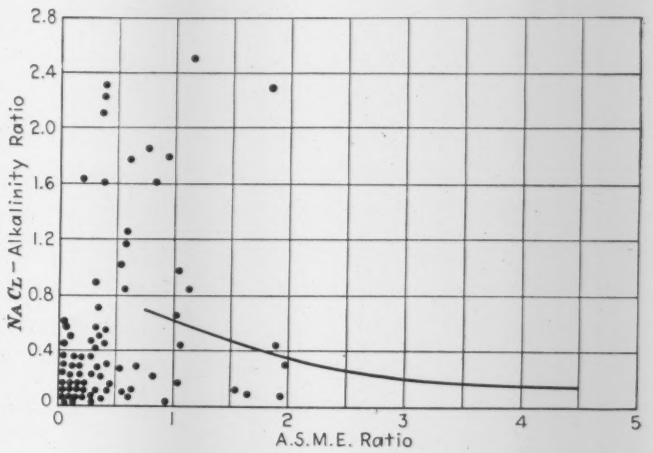


FIG. 2 INFLUENCE OF NACL AND NA_2SO_4 ON CRACKING
(Service record of failures at pressures between 100 and 250 lb abs.)

ratio, a higher sodium-chloride ratio was necessary in order to prevent cracking.

It is unfortunate that the authors have not, as yet, had an opportunity to explore more fully the area where the A.S.M.E. ratio is less than 1.0, as such an exploration might substantiate the thought that the amount of sulphate required increases as the amount of sodium chloride decreases and vice versa.

The line of demarcation between cracking and no cracking is not clearly defined but its apparent location is shown in Fig. 1, herewith.

A question which invariably arises in every case of laboratory research is: "What is the correlation between laboratory and plant?" To aid in answering this question, we have reviewed the data from every case of this type of failure, regarding which we have a complete record, and they are presented in Fig. 2.

Unlike the cases of Fig. 1 these are in the pressure range of from 100 to 250 lb abs. It is extremely interesting to note that every one of these points is at, or to the left of, the ordinate representing the A.S.M.E. ratio of 3.0. If a line is drawn similar to that in Fig. 1, it is found that 78 per cent of all failures are to the left, or below, this line. A great many of those above the line are in a region which the authors have not as yet explored.

We have records of boiler-water conditions covering many jobs where boiler-metal cracking of the type under discussion has not, to our knowledge, occurred. Data on these particular

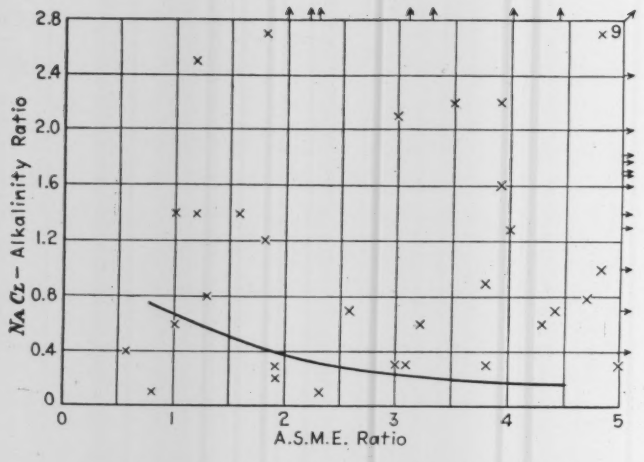


FIG. 3 INHIBITING INFLUENCE OF NACL AND NA_2SO_4
(Service record, no failures, pressures between 100 and 250 lb abs.)

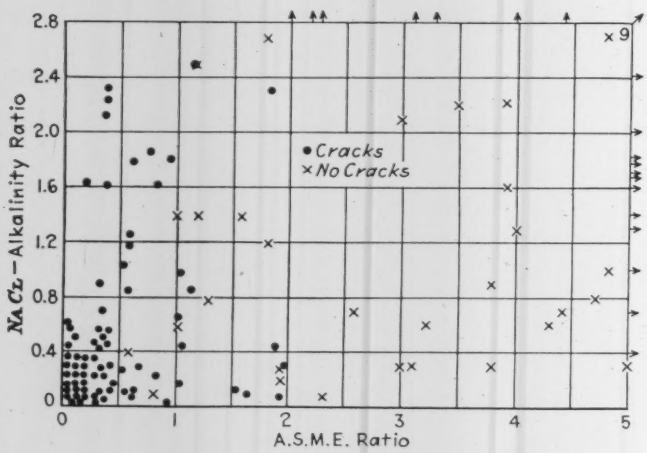


FIG. 4 INFLUENCE OF NACL AND NA_2SO_4 ON CRACKING
(Combination of Figs. 2 and 3.)

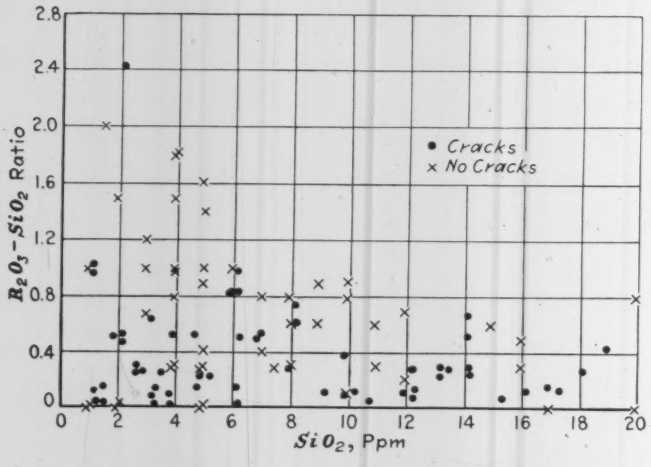


FIG. 5 INFLUENCE OF R_2O_3 AND SIO_2 ON CRACKING
(Service record at pressures between 100 and 250 lb abs.)

jobs are shown in Fig. 3. Few cases are below the line. A large number of the cases are far beyond the limits of the coordinates shown and are indicated by the arrows. It should be noted that these records cover the same period of time as those previously discussed and in no case do they cover internally caulked, seamless forged, or welded drums.

Fig. 4 is a combination of Figs. 2 and 3 and offers corroboration of the existing code ratio.

The authors show, in Fig. 8, the influence of R_2O_3, and SiO_2 on cracking at 470 F and 570 F corresponding to 515 and 1225 lb abs. Their data do not show any failures when the R_2O_3-SiO_2 ratio is above about 0.6, however, the lower ratios, particularly when the silica content is low, fail to produce cracking in some cases.

Although we do not have sufficient service records at these temperatures and pressures, we do have them in the range from 100 to 250 lb. Fig. 5 shows these data with reference to R_2O_3 and SiO_2, in cases where failures did and did not occur, in this range.

Although the plotted points cover different areas, there is a distinct tendency toward overlapping, much more so than was noted in the sulphate-chloride relation.

It is to be noted that most of the failures occurred when the R_2O_3-SiO_2 ratio was below about 0.6 or 0.8, whereas the cases where failure did not occur were, for the most part, where the ratio was above about 0.4.

W. C. SCHROEDER AND A. A. BERK DESCRIBE TESTS

Messrs. W. C. Schroeder[3] and A. A. Berk[4] wrote: The method of testing described in this paper marks another major forward step in the study of the intercrystalline or embrittlement cracking of boiler steel. The test demonstrates one method by which a dilute boiler water can be made to reduce the load-carrying ability of a steel specimen without resorting to concentration of the water by evaporation in a separate vessel.

The tests with this new equipment indicate that sodium sulphate is not universally applicable for the prevention of embrittlement; and substantiate, especially for the higher-pressure boilers, the conclusions reached by the writers[5] concerning the limitations on the use of this salt. This discussion considers further factors that may influence the apparent action of sodium sulphate in the boiler, as well as additional laboratory tests with sodium sulphate and sodium chloride.

ACTION OF SODIUM SULPHATE

If it is true that sodium sulphate is not a satisfactory protective agent the question immediately arises as to why the majority of boilers do not suffer from intercrystalline cracking. This problem is brought even more sharply in focus by the work in the paper. For example, a great many of the boiler waters were found to produce failure, and yet the great majority of the boilers using these waters have probably never encountered embrittlement troubles. This might be explained because the stress used on the testing equipment is probably much higher than that normally encountered in boiler steel. It has been demonstrated, however, that cold work in the metal without actual applied stress[6] is sufficient to cause cracking and this explanation does not seem entirely tenable.

Before considering the question in detail, a clear picture should be available of the mechanism that allows a dilute boiler water to concentrate to produce intercrystalline cracking. Test equipment described in this paper may produce such concentration but the exact steps in the process are not entirely clear.

Most operating engineers have, however, seen concentration

[3] Research Chemical Engineer, Joint Research Committee on Boiler Feedwater Studies, the Eastern Experiment Station, U. S. Bureau of Mines, University of Maryland, College Park, Md.

[4] Assistant Chemist, U. S. Bureau of Mines, College Park, Md.

[5] "Protecting Steel Against Intercrystalline Attack in Aqueous Solution," by W. C. Schroeder, A. A. Berk, and R. A. O'Brien, Trans. A.S.M.E., vol. 60, January, 1938, pp. 35–42.

[6] "Intercrystalline Cracking in Boiler Steel," by W. C. Schroeder, A. A. Berk, and C. H. Fellows, American Water Works Association, *Journal*, vol. 30, April, 1938, pp. 679–694.

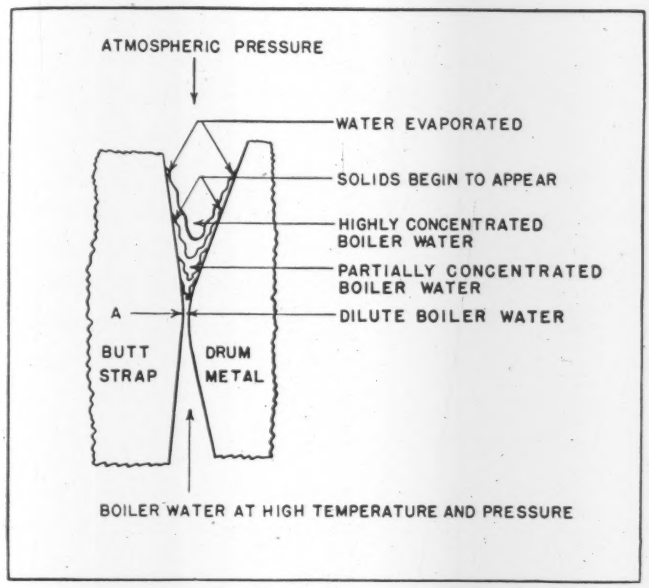


FIG. 6 GREATLY MAGNIFIED DIAGRAM OF A LEAK SHOWING CONCENTRATION MECHANISM

take place at the seams of a boiler by a process that can be easily explained. If the dilute boiler water leaks slowly past a riveted seam, it is exposed to atmospheric pressure when it reaches the edge and will evaporate to leave a deposit of solid at the seam edge. In this process the water has evaporated from a solution containing a few thousand parts per million of dissolved solid until a concentrated solution was produced, and with further evaporation such soluble salts as sodium sulphate and sodium chloride were deposited.

If this concentration occurs at the edge of a butt strap where stresses and cold work are absent it will probably do little damage. If it occurs down in the riveted seam, a different situation exists. Fig. 6 shows on a greatly magnified scale a small leak between the drum metal and butt strap of a boiler. Point *A* represents an actual opening so small that the boiler water can diffuse only slowly through it. As this diffusion occurs, the heat in the metal and in the liquid will cause evaporation toward atmospheric pressure, to produce a more concentrated solution. Still farther away from the opening more evaporation has occurred and the boiler water is quite concentrated. Next, solids such as sodium sulphate and chloride begin to crystallize from solution and finally substantially all the water is evaporated and solids are chiefly present. In the laboratory, at 200 lb pressure, it has been possible by this process to concentrate boiler waters containing from 500 to 2000 ppm of sodium hydroxide to solutions containing more than 600,000 ppm of sodium hydroxide.

From Fig. 6 it is apparent that the rate of leakage must be confined within certain limits to produce a concentrated solution. If no leakage occurs concentration is not possible. On the other hand, if opening *A* is too large the water will rush out so rapidly that evaporation will be far too slow to allow concentration. The most dangerous type of leakage is that which would allow an almost imperceptible loss of water vapor to the atmosphere.

On the basis of this concentration process, or others that may be pictured, at least the following factors enter into the production of embrittlement cracks:

1 A boiler water which when concentrated will produce intercrystalline cracking. The laboratory evidence now indicates that a water containing sodium hydroxide-sodium silicate will fall into this class if it does not contain an effective protective agent.

2 High stress in the metal. This may result either from cold work or external applied stress. In a riveted joint or rolled-in tube the effect of cold work would normally be more pronounced than the action of an applied stress.

3 Very slow leakage or other process taking place in certain areas of the boiler that will allow the formation of a film of concentrated solution.

4 Contact of the film of concentrated solution with the highly stressed boiler metal.

When embrittlement cracking is ascribed to the simultaneous action of at least four factors, it is possible to explain to a considerable extent the peculiarities surrounding its incidence in operating boilers. For example, boilers have operated for many years on highly alkaline waters that were not treated to prevent cracking. By all our present tests these waters would be judged as embrittling, but cracking has not been encountered.

This would indicate the absence of one of the last three factors which play a vital part. Batteries of boilers, taking feedwater from a common header, have reported cracking in only one boiler, with all the others entirely free from trouble. This again may be logically ascribed to the influence of factors other than the embrittling action of the water. Even more striking is the fact that cracking in a multidrum boiler is seldom encountered in all the drums. Here, the influence of variation of water composition is nearly eliminated, and the position at which cracking starts must depend on other factors.

The presence or absence of one or more of the last three factors that were listed may be just as important in metal cracking as the embrittling or nonembrittling nature of the boiler water. Therefore, even if sodium sulphate is not an effective protecting agent this does not necessarily mean that cracking will occur, for a boiler may operate with an embrittling water and yet never suffer cracking because leakage does not take place to just the correct limited extent and at just the right place to bring the concentrated sodium-hydroxide solution into contact with steel under high residual stress.

The use of operating evidence, that is, the lack of intercrystalline cracking in a boiler, to classify a water as nonembrittling may not be a satisfactory procedure at the present time. Such classification does not consider all the factors in the problem. This would seem to indicate that the statistical evidence from operating boilers on which our present A.S.M.E. code values are partially based is not altogether satisfactory.

ACTION OF MIXTURES OF SODIUM SULPHATE AND SODIUM CHLORIDE

As a result of using the new testing equipment described in the paper on a number of boiler waters the authors come to the conclusion that embrittlement will be prevented by the simultaneous presence of a sodium-sulphate content of 1.0 or more and a sodium-chloride content of 0.6 or more times the total alkalinity. This is believed to be especially true for pressures below 250 lb.

Tests run by the writers do not altogether agree with this conclusion. For example, in the tension-testing bombs using directly the concentrated alkaline solutions, the mixtures of sodium sulphate and sodium chloride do not seem to influence the failure time. This is shown in Table 1, on the following page. Failure was not prevented at any of the test temperatures in spite of the addition of considerably more sulphate and chloride than was necessary to satisfy the ratios of 1.0 and 0.6.

It is possible to contend that this method of testing is not satisfactory because the conditions that cause the dilute boiler water to concentrate and produce cracks are absent. The writers have attempted to remove this criticism by duplicating

TABLE 1 EFFECT OF SODIUM SULPHATE AND SODIUM CHLORIDE ON THE FAILURE OF CONCENTRIC GROUND SPECIMENS

(Specimens of boiler-flange steel)

Specimen number	Stress, lb per sq in.	Grams per 100 grams H_2O				Failure, hours	Temperature, deg C	Pressure, lb per sq in.
		NaOH	Na_2SiO_3	NaCl	Na_2SO_4			
62.114	60,000	25	0.32	25	75[a]	17	250	560
62.117	60,000	25	0.8	25	75[a]	31	250	560
62.126	50,000	40	1.0	40[a]	80[a]	84	225	350
62.127	50,000	40	2.0	40[a]	80[a]	79	225	350
62.124	50,000	40	0.5	40[a]	80[a]	95	200	215
62.125	50,000	40	1.0	40[a]	80[a]	238	200	215

[a] Indicates amount added. This exceeds solubility.

TABLE 2 FAILURE OF SPECIMENS IN THE CONCENTRATION TESTS IN SOLUTIONS TREATED WITH SODIUM SULPHATE AND SODIUM CHLORIDE

(Specimens of low-carbon cold-rolled steel. Temperature, 180 C. Pressure, 130 lb gage. Spring stress, 45,000 lb per sq in.)

Specimen number	Water composition, ppm				Test result
	NaOH	Na_2SiO_3	Na_2SO_4	NaCl	
41	500	25	..	500	broken 3 days
38	500	25	1000	300	broken 11 days
74	500	25	1000	300	broken $2^1/_2$ days
37	500	25	1000	500	broken 1 day
54	500	25	1000	500	broken 1 day
79	500	25	1000	1000	broken $1^1/_2$ days
40	500	25	1000	2000	cracked 4 days[a]

[a] Specimen so badly cracked when examined at end of this time that reloading was unnecessary.

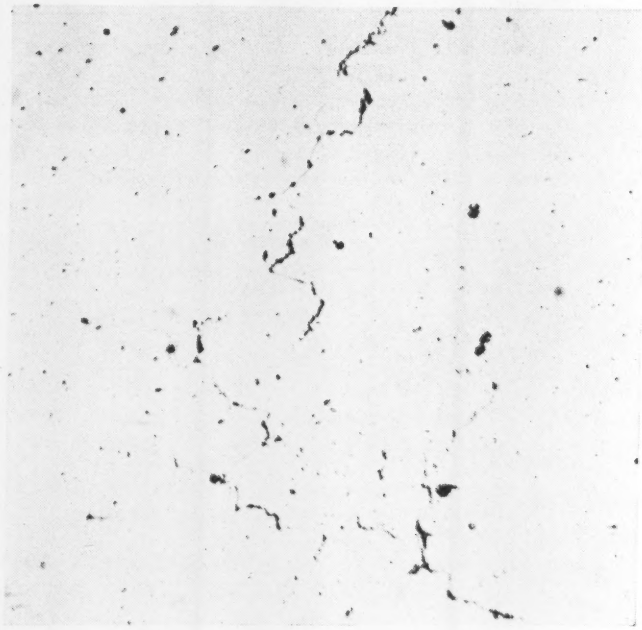
these tests in equipment that did produce such concentration.

In the first section of this discussion, a method of concentration was presented that involved the slow diffusion of the dilute boiler water past a restriction and evaporation on the low-pressure side of the restriction. By using this concentration principle, equipment has been constructed that will allow the direct testing of a boiler water or synthetic solution for its action in the production of intercrystalline cracks. With a 45,000-lb spring stress on the specimen, solutions containing from 200 to 2000 ppm of sodium hydroxide and some silica would readily produce failure at 180 C. Under these same conditions water alone would not produce failure even with a 60,000-lb stress.

Table 2 shows the results of a series of tests in this equipment with sodium hydroxide-sodium silicate solutions also containing sodium sulphate and sodium chloride. Failure or cracking was encountered in every case, and the time was not measurably different from that found in similar solutions in the absence of sodium chloride. The first test solution contained sodium chloride but no sodium sulphate. The sodium chloride did not influence the failure time. In tests nos. 38 and 74 the ratios of sodium sulphate and sodium chloride to total alkalinity were 1.5 and 0.46, respectively. Failure occurred in both cases although one specimen did run for several days longer than normal time. The last five solutions, all containing ratios of sodium sulphate and sodium chloride to total alkalinity considerably greater than 1.0 and 0.6, respectively, were broken or severely cracked in less than 4 days.

Specimens of cold-rolled steel were used for all the tests shown in Table 2.[7] Intercrystalline cracks are found in areas of boiler metal that have suffered cold work during fabrication. For example, the metal under rivet heads, along the rivet holes, and the rivet itself are cold-worked during the construction of the boiler. The tubes are cold-worked during rolling. These areas are usually the ones where intercrystalline cracking starts. To these residual cold-work stresses may, of course, be added any applied stress resulting from steam pressure or other factor. It seems necessary that a chemical treatment prevent embrittlement in the presence of cold-work stresses if it is to be effective in a boiler. The sodium sulphate and sodium chloride do not fulfill this requirement.

Fig. 7 shows the type of cracking produced in these specimens in the solutions containing sodium sulphate and sodium



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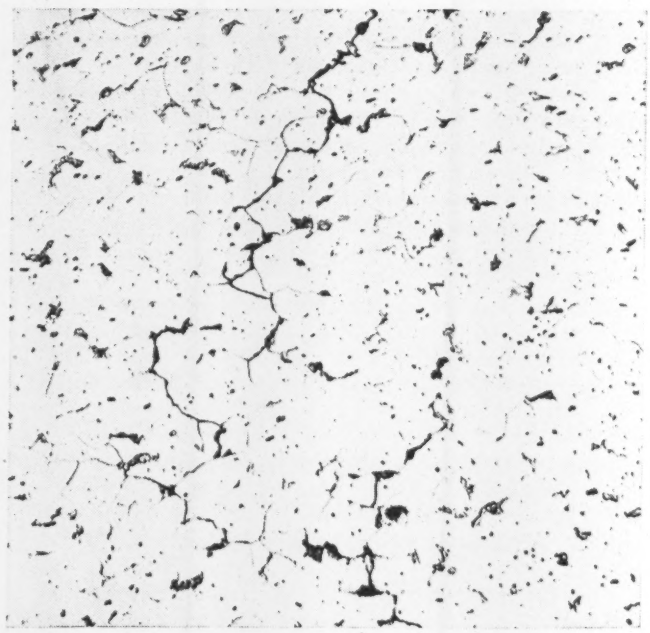

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FIG. 7 INTERCRYSTALLINE CRACKS PRODUCED BY ACTION OF A TEST SOLUTION

(Composition of solution: 500 ppm NaOH, 25 ppm Na_2SiO_3, 1000 ppm Na_2SO_4, and 1000 ppm NaCl. Magnification 300×.)

[7] Since this discussion was written these tests have been repeated substituting specimens made of boiler-flange steel for those made of cold-rolled steel. High concentration of sodium sulphate and sodium chloride did not prevent intercrystalline cracking and fracture under a 45,000-lb per sq in. load.

chloride. It is almost completely intercrystalline, and the photomicrographs certainly will not support the belief that sodium sulphate and sodium chloride will prevent intercrystalline cracking in steel. The photomicrographs are cross sections of the specimens and they do not indicate the elongation of the crystals resulting from the use of cold-rolled steel as much as would a longitudinal section.

The history of a 385 hp 3-drum boiler operating at 100 lb pressure is also of considerable interest with regard to the action of sodium sulphate and sodium chloride in preventing embrittlement. In its first three years of operation this boiler cracked about 200 water-circulating tubes at the seats in the upper drums. The drum metal at the tube seats was also cracked, and in the second year one drum was replaced because cracking had progressed too far into the tube ligaments. The new drum also developed cracks at the seats, and tubes continued to crack off in spite of attempts to keep the hydroxide concentration in the boiler water low. Since the feedwater naturally contained considerable sulphate and chloride, the maintenance of low alkalinity resulted in high ratios of these salts to the total alkalinity. During the last 9 months of operation the reported analyses show the ratio of sodium sulphate to total alkalinity varying from 2.9 to above 20 and the ratio of sodium chloride to total alkalinity varying from 2.3 to above 10. These high ratios did not prevent cracking of tubes in a few weeks after their installation. Microscopic examination of both tubes and drum metal indicated that the cracking was largely intercrystalline. The experience with this boiler offers little support for the use of sodium sulphate or sodium sulphate and sodium chloride for the prevention of embrittlement.

The writers would like to congratulate the authors on the development of their new testing unit and to suggest only that care be used in interpreting the results and applying them to operating boilers.

M. C. SCHWARTZ RECOMMENDS HARD-RUBBER BOTTLES FOR SAMPLES OF BOILER WATER

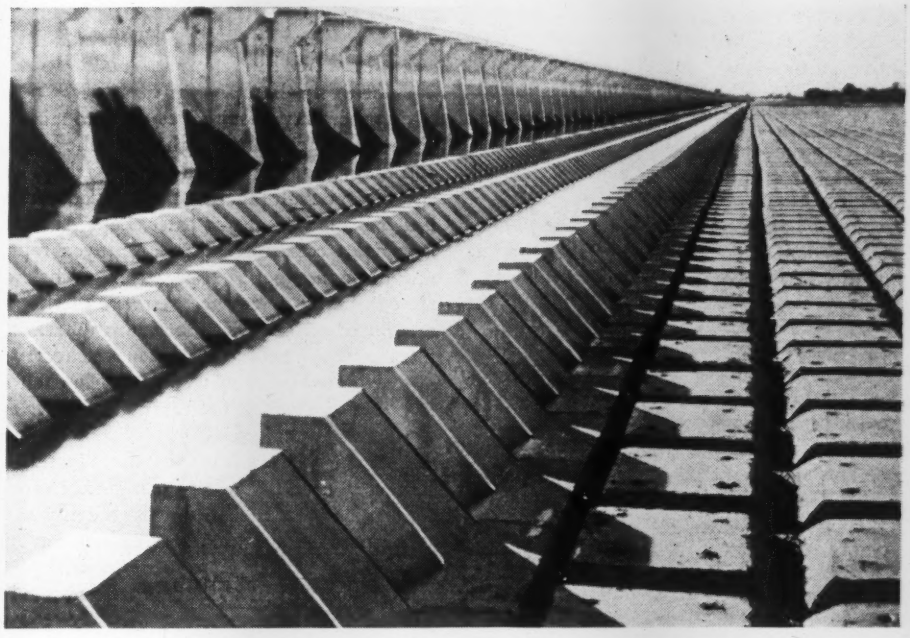
M. C. Schwartz[8] wrote: The increase in the number of chemical reagents involved in the formation and prevention of embrittlement has given rise to a need for accurate determination of all the substances concerned. It is interesting to note that the examination of boiler waters is to be undertaken for interested parties. Under such circumstances the material of the container used for shipment may alter the chemical composition of the solution. Tin-lined containers, according to our experience, react with alkaline boiler waters to dissolve sufficient tin, e.g., to reduce the silicomolybdic acid formed in determining silica colorimetrically. The writer would like to recommend hard-rubber bottles, after a short period of aging, as being suitable containers for the transportation of alkaline boiler waters.

[8] Research Chemist, Louisiana Steam Generating Corporation, Baton Rouge, La.

AUTHORS' CLOSURE

The operating results which are reported by J. B. Romer appear to agree well with the laboratory test results which we have reported, particularly in regard to the chloride and sulphate effect on prevention of embrittlement in the pressure ranges below 350 lb. The fact that there is no relationship between the R_2O_3 and silica content and embrittlement in Mr. Romer's data is due to the fact that all of his data are in the lower pressure range. Our laboratory results indicate that the R_2O_3-silica ratio also has no effect in this lower pressure range.

It is rather difficult to discuss the results reported by Schroeder and Berk due to the fact that they do not describe the apparatus which they use. Their statement that, "If no leakage occurs concentration is not possible," is in direct contradiction to the results we have reported. We have found this concentration to take place in all of our tests without any leakage occurring. A laboratory test of this nature to be of any industrial use must be correlated with actual operating experience. The results which we have reported from our tests appear to indicate that in the lower pressure range the maintenance of the A.S.M.E. ratio, which has protected many operating boilers from embrittlement, also prevents embrittlement in our tests. In the event that the authors' tests could not be correlated with actual operation, they would not be of much service to the industry.



BONNET CARRE SPILLWAY, A NOTEWORTHY NEW ORLEANS FLOOD-CONTROL PROJECT

(A.S.M.E. Spring Meeting will be held at New Orleans, Feb. 23–25, 1939. For program see page 175 of this issue.)

INDUSTRIAL RELATIONS *in* AUSTRALIA[1]

By W. RUPERT MacLAURIN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THERE ARE enough similarities between Australia and the United States to make the Australian experience with compulsory arbitration of industrial disputes of interest to American readers. This experience has been recently described in detail by O. de R. Foenander, a barrister and solicitor of the Supreme Court of Victoria, and a lecturer in history and economics at the University of Melbourne.

Although Australia has a population of less than seven million, the Australian continent is approximately the same size as the United States and affords a wide variety of climatic and occupational conditions. Fostered by a high tariff, industrial production in Australia has increased to a point where the occupational division of the population is quite similar to that in the United States. The Australian constitution, furthermore, was partially modeled on the Constitution of the United States, and provides for a federal supreme court which has preserved a somewhat similar division of powers between the federal and state governments.

The development of the arbitration system in Australia dates back to 1895, when the Labor Party added to its platform a new plank of compulsory arbitration. There were two principal reasons in Australia for the introduction of public regulation into a field of industry hitherto covered with but moderate success by free contract—the desire to avoid the consequences of industrial disputes, and the wish to prevent the payment of sweated wages.

The Commonwealth Court of Conciliation and Arbitration, which is the most important arbitration tribunal in Australia, was established in 1904 in accordance with the provision of the federal constitution empowering the Commonwealth Parliament to make laws with respect to "conciliation and arbitration for the prevention and settlement of industrial disputes extending beyond the limits of any one state." In addition to the Commonwealth Government each state has its own industrial laws and its own industrial tribunals. The Commonwealth Court has no power to arbitrate in disputes that are entirely confined to one state. Such disputes come under the jurisdiction of the state tribunals.

Because of the existence of both state and federal tribunals it is difficult to present a clear picture of the arbitration system as a whole. In general, however, the procedure consists of:

(1) The fixation of minimum wages for unskilled and skilled workers in almost all occupations throughout Australia.

(2) The legal recognition of collective agreements relating to wages and working conditions entered into voluntarily. The courts encourage employers and organizations of employees to make industrial agreements and to file them with the court for the purpose of giving them the force of awards of the court.

(3) The failure to reach a voluntary agreement in a dispute leads to a compulsory arbitration procedure. The parties to a dispute appear before the court and evidence is taken from both sides. The court then makes an award which is binding on both parties. Penalties are fixed for violation of the award of the court.

Mr. Foenander confines the discussion in his book primarily to the activities of the Commonwealth Arbitration Court. He writes about this tribunal with great respect and pride which may easily be justified. But the major criticism of his book is that it does not raise more questions about the effects of compulsory arbitration on industrial relations in Australia.

And yet there is some disquieting evidence presented in Foenander's book on the effects of compulsory arbitration. Thus he writes that "hearings in a dispute are a lengthy process, and it is no unusual spectacle for a matter to be actually before the Court for the greater part of a year before an adjustment or a modus vivendi is arrived at. . . . . But it is in the psychological reactions that legalism is apt to have its most unfortunate results. The machinery of the Act renders it imperative in practice that employers and employees should organize, and the appearance of these rival associations in Court as antagonists undoubtedly widens the breach between the parties. There is thereby created a class consciousness, and hostility is engendered to take the place of sympathy. Industrial peace is expected to emerge as the 'by-product of a fight.'"

It is in fact open to question whether the Australian arbitration system has made for a reduction in industrial disputes. In their awards affecting working conditions, the arbitration courts have provided protection and fair treatment to the workers and removed some of the causes of industrial friction without seriously hampering the operating efficiency of private enterprise. Against this is the probability that the system, if it has not actually heightened the cleavage between capital and labor, has not served to bring them closer together. Thus, the early development of compulsory arbitration in Australia has, to some extent at least, kept Australia from pursuing the American experiments in employee representation plans and union-management cooperation. While there can be no doubt that in many cases the existence of the arbitration system has prevented strikes, it is uncertain whether the same result could not have been accomplished more effectively by some voluntary system of arbitration set up within each industry as a result of a mutual agreement between employers and the unions in that industry.

In wage determinations the Australian arbitration courts have succeeded in eliminating excessively low wages and in maintaining a considerable degree of wage flexibility in the face of a strong and articulate trade-union movement. The court fixes the lowest sum payable to unskilled workers and to the various classes of skilled workers, leaving to free bargaining between the worker and his employer the extra amount to be paid to a worker who possesses special skill or other special qualifications in his class. While any worker in Australia has

[1] "Towards Industrial Peace in Australia," by O. de R. Foenander, Melbourne University Press, 1937. Some of the material included in this book review has already appeared in the reviewer's article entitled, "Compulsory Arbitration in Australia" in the *American Economic Review*, March, 1938.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

the right to refuse to work for any employer at the minimum wage, it is a violation of the Commonwealth Arbitration act for individuals in combination to try to compel employers to pay more than the minimum rate.

The Commonwealth Court also regulates hours of work for the workers that come under its jurisdiction. The general standard now accepted is 44 hours per week, although awards vary according to the industry. It is not the practice of the Court to reduce wages in an industry on account of a reduction in the weekly hours worked in that industry.

The Commonwealth Court has a dominant position in the Australian wage economy because the state tribunals tend to follow its lead in the determination and adjustment of minimum wages. In the Harvester Judgment of 1907 Justice Higgins ruled that to be "fair and reasonable" a wage must be sufficient to satisfy "the normal needs of an average employee regarded as a human being in a civilized community." The first minimum wage established in 1907 was 42 shillings per week for unskilled workers. This minimum wage for unskilled workers is known as the "basic" wage. It was determined originally to meet the needs of an unskilled worker with a wife and three children. Margins above this were provided for skill or for other special reasons. Since 1907 the tendency has been to bring an increasing proportion of employees under wage-fixing tribunals, but the basic wage has not been raised, except for a special increase of about 7 per cent in 1921. In order to maintain real wages from year to year the practice has grown up in the Commonwealth Court of adjusting wages to the cost of living every three or six months, according to the award, on the basis of a food and rent index number compiled by the Commonwealth Statistician for the city or town in which the persons affected were employed.

In the 1920's there was considerable criticism of the steadily mounting trend of wages. This was a period in which the Australian tariff rose progressively. The tariff contributed to advancing the cost of living; and higher prices were in turn reflected in higher wages. As costs were raised, secondary industries applied for additional tariff protection, which was granted in a number of instances.

This vicious circle of mounting costs and tariffs was broken in the depression. Not only did the cost of living fall rapidly, thus reducing wages, but the Commonwealth Court declared in January, 1931, that the fall in the national income was so severe that some additional reduction in wages was necessary. It therefore decreed a special reduction of 10 per cent in wage rates, to be put into effect immediately. Although the labor movement has not accepted the Court's arguments in favor of wage reductions in the depression as valid, the discussion by the Court in 1931 of the necessity for wage reductions in view of the fall in the national income appears to have been of very considerable value in promoting an understanding of the economic situation of the country among a large section of the electorate. From the beginning of the depression the Court has taken more notice of fluctuations in economic conditions than almost any other official or semiofficial body in the country.

Although doubts may be raised as to the desirability of adjusting wages automatically according to fluctuations in the cost of living without direct relation to the productivity of labor and the capacity of industry to pay, the cost-of-living principle is easily understood and is generally accepted as desirable by the Australian labor movement. It also provides a semiautomatic guide for the Commonwealth Court to follow under ordinary circumstances, although the Court has made occasional changes in real wages when it considered that general economic conditions demanded it. Thus real wages were raised in 1921 by 7 per cent, lowered in 1931 by 10 per cent, and raised again by about 6 per cent in 1933 and 1934 and by an additional 6 per cent in 1937.

CONCLUSION

Mr. Foenander's book does not give us much basis for judging whether the Australian system of compulsory arbitration and wage fixation should be adopted elsewhere. It remains therefore a matter of opinion as to whether the United States should undertake a similar experiment. If it has proved difficult to administer a system of compulsory arbitration for 7,000,000 people, the problem would be vastly magnified in the United States. It would appear desirable, therefore, for us to experiment further with voluntary arbitration methods before committing ourselves to any such system. Once adopted, compulsory arbitration is likely to interfere with the development of the best spirit of cooperation between capital and labor. Yet, we in this country may eventually have to accept it unless we can find a workable compromise between the extreme positions that have been adopted in the past by both labor and capital.

In the regulation of minimum wages we could profit perhaps by Australian experience. Here again, however, it would seem desirable to experiment as we are now doing with a "basic" wage designed to provide a "fair and reasonable" standard of living and leave the provision of margins for skill to the play of economic forces. So far as the method of adjusting the minimum wage is concerned, I am inclined to believe that the Australian system of automatic regional cost-of-living adjustments checked periodically by reference to general economic conditions is the most practical method of administering a national minimum wage. The understanding of general economic conditions shown by the Commonwealth Court in recent years indicates that a properly administered minimum-wage law may add a valuable element of flexibility and control in the business cycle.

Progress in Railway Mechanical Engineering

THE CHAIRMAN of the A.S.M.E. Railroad Division Committee RR6 Survey, has requested the publication of the following corrections and additions to the article "Progress in Railway Mechanical Engineering, 1937–1938," which appeared in MECHANICAL ENGINEERING for December, 1938, pp. 909–920.

Table 4 on page 914:

The *Rebel* of G.M.&N. has six 8 × 10-in. cylinders and develops 660 hp at 740 rpm.

The New Orleans Public Belt Locomotive has a 900-hp, eight-cylinder VO-type engine with $12^1/_2 \times 15^1/_2$-in. cylinders; the weight is 246,000 lb; maximum tractive force (30 per cent adhesion) 73,800 lb; continuous rating, 29,500 lb at 8.94 mph.

The Youngstown and Northern locomotive has $12^1/_2 \times$ 13-in. cylinders and weighs 233,500 lb. Maximum tractive force, 70,000 lb; continuous tractive force 33,600 lb at 8.1 mph.

The Roumanian Government locomotive has two engines of 2200 hp each.

The Reichsbahn train is not strictly classified as a locomotive-and-train unit, since the traction motors are distributed between the first and fourth cars, and the engine is in the first car. The motors are nose-supported and drive through the normal gearing arrangement.

Recent PROGRESS *in* AERONAUTICS

I—Development in Meteorology

By ATHELSTAN F. SPILHAUS

NEW YORK UNIVERSITY

THE SCIENCE and practice of meteorology has recently suffered a severe loss occasioned by the death of Dr. Willis Ray Gregg, chief of the United States Weather Bureau. Within the Bureau advances were rapidly being effected according to his progressive policies while in other meteorological organizations, whether connected with the air lines or academic institutions, activity was stimulated by his sincere interest and helpfulness. As a leader in a science so utterly dependent upon cooperation, Dr. Gregg set a high objective by his personal example.

Perhaps one of the more significant although less conspicuous phases in the development during the last year is the advance which has been made in international cooperation. Although the standardization of meteorological practice is still far from being complete, the groundwork has been firmly laid and the various commissions of the International Meteorological Organization have served to render every meteorologist conscious that the scope of his phase of geophysics is world scale and transcends political boundaries.

It is natural that a major development within the United States in meteorology should be directed toward a further improvement in the quality of aerological observations, that is, those observations of conditions not in the immediate vicinity of the ground. Along these lines, and benefiting by the work of Harvard's Blue Hill Observatory, the California Institute of Technology, and the U. S. Bureau of Standards in the evolution of the instruments, the Weather Bureau established, in July, six radiometeorograph stations, which provide with regularity, fair weather or foul, observation of the meteorological conditions well into the stratosphere. Already in 1936 with a network of 25 stations making regular airplane meteorograph flight, the United States Bureau was regarded with envy by the foreign weather services; and while the establishment of the radiometeorograph stations will go far to maintain this position, it is a great pity that concurrently with their introduction came what was tantamount to a breakdown of the aerological network. The most serious contributing factor in this was the withdrawal of the Army from the program. This withdrawal resulted in the abandonment of the collection of upper-air data at seven stations. Even if radiometeorograph stations are put in by the Army in their stead, the full number of stations will not be operative for a considerable time. It is the intention of the Navy to operate one other radiometeorograph station in addition to the one which they now have at Anacostia, D. C. Furthermore, it is to be regretted that in the case of the radiometeorograph stations established by the Bureau, they were put in to replace the well-established airplane stations, and lack of additional funds prevented the running of both systems simultaneously until such a time as satisfactory intercomparison was complete. Thus, while these changes are progressive in trend, they are, temporarily at least, detrimental for current practice.

Other determinations of conditions in the upper air have been made and have been accompanied by a great measure of success, notably the sounding-balloon series made during the international month (July, 1938). Not only were the ascents of a greater accuracy than previous series, but both the average elevation reached (circa 24 km) and the highest elevation (31 km) exceeded former marks. The series has not yet been analyzed, but cursory inspection of the results indicate a wealth of material of foremost interest. It is evident that this promotion of the aerological work is of prime importance to air transportation, but the Bureau has not neglected its surface network. The increase of stations in the surface network has been greater in the last year than in many previous years.

It is not easy to separate the contributions of the air lines to the development of meteorology from those of the Bureau. Requirements of the air lines are so exacting that for their demands to be satisfied necessarily means a continual improvement in the quality of weather data. More important is the fact that even the smaller air-transport companies now realize the advisability of employing trained meteorologists. Important data regarding ice formation on aircraft are being accumulated and analyzed by the air lines. The urgency for considerable improvement of observations at sea has been called to general attention by the proposed establishment of transatlantic air service. Evidence of the growth of interest in aviation circles with respect to meteorology was revealed in the splendid meeting organized by the Kansas City Seminar of the American Meteorological Society.

Advances made by the meteorological divisions of certain academic institutions in the last year have been considerable and only a few of the major points can be mentioned. A new approach to the analysis of weather conditions (isentropic analysis) has been developed at the Massachusetts Institute of Technology by Prof. Rossby and his coworkers. The potentialities of analysis on surfaces of constant entropy, which form the natural hydrodynamic surfaces, are great, and already the number of practically useful results of these investigations is sufficient to warrant the routine use of isentropic charts in a number of meteorological offices. The work at the California Institute of Technology in the development of the radiometeorograph has resulted in the adoption of the instrument by the Army. A significant indication of the growing importance of meteorology as a profession is the establishment of a separate Department of Meteorology at New York University, which provides complete undergraduate and graduate training. A policy providing for the schooling of selected Weather Bureau employees has been established under the Civil Aeronautic Authority and one or more men have been sent for advanced study during this academic year to each of the three institutions which provide such training, namely, California Institute of Technology, Massachusetts Institute of Technology, and New York University.

In conclusion, the contributions of the River and Flood Division of the Weather Bureau and of the Soil Conservation Service of the Department of Agriculture in the development of the interrelated problems of hydrology and meteorology should be mentioned. An outstanding example is the accomplishment by

Progress Report of the Aeronautic Division presented at the Annual Meeting, New York, N. Y., December 5–9, 1938, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

the River and Flood Division of what amounts to a complete reorganization of the flood forecasting in cooperation with the Pennsylvania Water and Power Resources Board. This, however, is only one of the numerous and highly successful projects the division has undertaken. The Soil Conservation Service, in its study of the climatic control of erosion, has set up a most intensive meteorological program in connection with such investigations as the one being carried out near Coshocton, Ohio. The detailed nature of the work may be indicated by the fact that on this experimental watershed over 100 rain gages are set up at points roughly 600 yards apart. Such data will be of tremendous interest to meteorologist and hydrologist alike.

In this brief account, only a few of the important advances have been mentioned, but they may be sufficient to indicate the trend which meteorology is taking in its rapid development.

II—Development in Airplane Design

By RICHARD M. MOCK

REPRESENTATIVE OF THE NETHERLANDS FOKKER AIRCRAFT COMPANY, LOS ANGELES, CALIF.

THE EXTERNAL appearance of the new aircraft developed in the year 1938 was not greatly different from that of previous years. However, there were a great number of important refinements and improvements, most of which affected safety. In addition, the size of the aircraft developed increased appreciably.

Landplanes and flying boats, larger than any ever built heretofore, were completed and test flown; and, as the year comes to a close, are about ready to go into commercial air-line operation. Larger airplanes have been built in previous years, but none of these were designed for regular daily use.

Possibly the three most outstanding developments for 1938 were the Boeing 314 four-engine flying boat,[1] the Douglas DC-4 four-engine landplane,[2] and the German Focke Fw 61-Bramo 14a helicopter.

FACTORS AFFECTING SAFETY

Among the large airplane designs it is apparent that there will shortly be an increasing controversy as to the minimum number of engines necessary for safety. It is generally accepted that from a pay-load and operating-cost viewpoint the most economical airplane is the largest airplane that can be built with the fewest number of engines. However, from the viewpoint of safety, the safest airplane is the airplane that can fly satisfactorily after the failure of the largest number of engines. As safety affects traffic, and the volume of traffic in turn affects air-line revenue, the question of safety is closely allied with that of operating economy.

In 1938 a number of previously tried ideas were applied to actual practice. The most notable of these was that of the nose wheel as applied to the transport airplane. The first commercial transport to have this device was the Douglas DC-4. By having the single wheel in front of the two main wheels the airplane is inherently more stable on the ground, thus giving greater safety during take-off, landing, and taxiing. In addition, its inherent stability makes it very desirable for airplanes required to make blind landings. Besides, the shorter possible landing run with the nose wheel means increased safety for landing or getting back into a small field should engine failure occur during take-off. On the other hand, if the gross weight is to be extended so that the landing run will be the same as obtained with the hitherto conventional landing gear, the pay load is increased accordingly. The Douglas DC-4 of 60,000 to 65,000 lb gross weight is the only commercial transport completed up to now with the nose wheel, though it seems that most new transport projects will have landing gears of this type. On the large airplanes the nose wheel has been free to turn, making the gear inherently stable and not steerable, though an emergency steering device has been considered to allow ground looping of the airplane to avoid emergency collisions on the ground. On small airplanes the steerable nose wheel has been tried.

[1] Weighing about 95,000 lb.
[2] Weighing about 65,000 lb.

VARIOUS FEATURES OF DESIGN

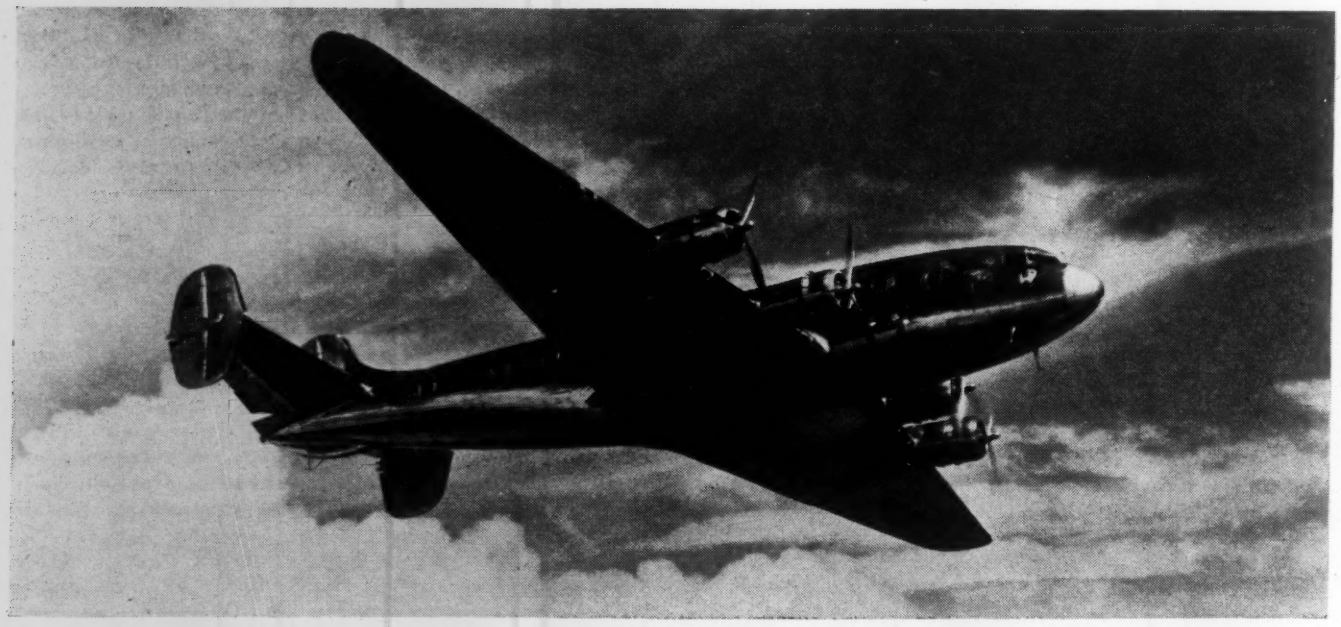
During the year considerable study and attention was given to the design of pressure cabins for transport airplanes. Lockheed's XC-35, built for the U. S. Army during 1937, was flown considerably and a great number of tests were run with it. Nearly all of the transport manufacturers, including Boeing, Douglas, and Curtiss-Wright, had designs for ultimate installation of pressure cabins for their new transport types.

In general arrangement, there was a tendency toward the return to the high-wing type of airplane, though no new high-wing designs of importance were completed in the United States during the year. The low-wing type became popular at about the time of the general use of the retractable landing gear, the low wing being an excellent location for the housing of the retracted undercarriage. However, with increased experience in landing-gear design and improved material, it has been possible to consider longer landing gears, allowing the high-wing designs, with improved visibility, and elimination of certain flying characteristics of the low-wing type.

On multiengine airplanes the trend was definitely toward multiplicity of vertical tail surfaces. Early in the year the improved Martin flying boat Model 156 was flown, and unlike the previous machines, this had twin tails. Toward the end of 1937 the Consolidated XPB2Y-1 four-engine flying boat was flown with single fin and rudder; and later, after much testing, a new tail was developed having vertical surfaces mounted on the tips of the horizontal stabilizer. The Douglas DC-4 was originally designed with three vertical surfaces and three sets of rudders. The original reason for this was the air-line requirement limiting the over-all height of the airplane and necessitating a multiplicity of vertical surfaces in order to get sufficient area. The Boeing 314 four-engine flying boat was originally flown with only a single vertical tail surface, but at the end of these flying tests had three vertical fixed surfaces and two vertical movable control surfaces, the extra fixed surface being in the middle above the hull.

In the design of large airplanes considerable attention was devoted to booster power controls. The Boeing company solved this by applying the pilot's forces directly to the movable tab at the trailing edge of the control surface. In contrast, the Douglas company kept the conventional control mechanism, but used a hydraulic system to help increase the control forces under certain conditions.

Another phase of airplane design which heretofore received little consideration was to eliminate the accretion of ice on the



DOUGLAS DC-4 IN FLIGHT WITH TWO ENGINES STOPPED

fixed and movable external parts of the airplane. Originally, airplanes could not fly under icing conditions because of accumulation of ice on the wings and reduction of power. With the advent of the rubber deicer overshoe to eliminate ice on the leading edge of the wings and fixed tail surfaces, plus the elimination of ice in the carburetor, and slinger rings to prevent ice from accumulating on the propeller blades, it was possible for airplanes to fly under icing conditions. However, the accumulation of ice on leading edge of control surfaces, pitot masts, and the like then became a serious problem; and after considerable study and testing in the refrigerated wind tunnel of the B. F. Goodrich Rubber Company, various design principles were evolved so that these secondary hazards could be eliminated.

Another design feature which heretofore was only considered to a minor extent was the question of the vibration of the airplane. During 1938 Hamilton Standard perfected its method of measuring vibration in propellers by the use of a small carbon pile attached to the propeller blade, which changed its resistance when elongated or contracted due to deflections in the propeller blade. The same method was applied to the study of vibration of the propeller hub, while conventional vibration recorders were used for the study of vibration in other parts of the structure.

The question of smoothness of external surfaces continued to receive attention, and the general trend was to have countersunk riveting wherever practical and where it could be afforded.

DEVELOPMENT IN MATERIALS

Aluminum alloys continued to be the principal airplane material. Magnesium alloys continued to be used in only small quantities in the United States of America, but in an increasing amount in Europe. Welded steel tubing continued to be the standard type of structure for engine mounts and landing gears. Of interest during the year was the German Blohm and Voss HA-140, having a single tubular spar in the wing. This large-diameter tubular spar was constructed of welded flat sheet and was used as a gasoline container.

In the United States of America the semimonocoque type of construction of fuselages continued to be general practice, with most stringers being continuous, and the stringers made of extruded material. In wing construction there was an increased tendency toward single-spar designs, with a reinforced metal skin. There were some stainless-steel wings built, but the quantity was not appreciable. Fabrication of aluminum-alloy parts was chiefly by riveting, and spot welding continued to be used only in secondary structures except in isolated cases. Of interest was the German Heinkel "detonation riveting," consisting of having a small quantity of explosive in a hollow rivet so that this could be discharged electrically, expanding the shank of the rivet to facilitate blind riveting.[3] Wood increased in use for small airplanes, and the one outstanding application of wood design was the development of the de Haviland *Albatross*, having a wooden fuselage.

There was a continued interest in plastics, though the extent of their use in aircraft construction continued about the same. There was considerable research and study in the application of plastics and plastic-impregnated materials for use in primary structures.

ACCESSORIES

In the accessory field the general application of the full-feathering propeller on multiengine airplanes was of great importance in 1938. In addition to improving the performance of the multiengine airplane with one engine stopped, the full-feathering propeller enabled the pilot to stop the engine at will, reducing hazards from excessive engine vibration following engine failure, and also improving airplane flying characteristics with one engine stopped. The most common was the Hamilton Standard hydraulically operated hydromatic propeller; while many military applications employed the Curtiss-Wright electrically operated propeller. The U. S. Army made tests on a Curtiss pursuit plane having counter-propellers on a single shaft, rotating in opposite directions. This had been designed in previous years in Italy and in Holland.

Of interest during the year was the test by the Vega Airplane Company (Lockheed subsidiary) with two air-cooled in-line engines mounted side by side and driving a single propeller through a gearbox with a suitable clutch arrangement. A number of flight tests were made with this unit, and as the year

[3] See MECHANICAL ENGINEERING, October, 1938, pp. 767–768.

came to a close the design of the first Vega airplane with this type of power installation was nearing completion.

A development which came into general use in 1938 on larger airplanes which had been carried over from previous years was the use of alternating current for electrical supply. There was no definite standard, as both 115-volt, 400-cycle, three-phase and 115-volt 800-cycle, single-phase current sources were used. By having alternating current of high voltage there was much better flexibility and considerable weight saving on airplanes, when compared with the 12-volt direct-current system previously used. Nearly all large airplanes had auxiliary power plants, the DC-4 having two completely automatic Eclipse units.

Of interest during the year was the German Dornier DO26 four-engine flying boat having two tandem engine nacelles with the two rear engines mounted so that they could be raised to keep them out of the spray from the forward propellers.

An interesting experiment was that of McKinley, using pneumatic floats on a Piper Cub light airplane.

The use of hydraulic systems continued, and the application of hydraulic pressure in airplane operation increased. Pressure hydraulic systems continued to be used for landing gears, cowl flaps, nose-wheel centering devices, nose-wheel damping devices, wheel brakes, auxiliary engine starters, fuel-pump drives, and control surface boosters. Hydraulic systems were of both direct-motor-operated pressure-pump systems and the pressure-reserve-tank systems storing energy to meet large demands of power for short periods.

As the year came to a close Curtiss-Wright was rushing completion on its Model 20, a large two-engine passenger transport. Also nearing completion was the Boeing 307, which is expected to be the first passenger transport in operation with pressure cabin. The French Latecoere six-engine 140,000-lb flying boat was under construction. A flying model of this project had been tested. During 1938 Pan American Airways had announced a design competition for 100-passenger flying boats, and designs were submitted by the leading aircraft manufacturers.

III—Development in Power Plants

By C. FAYETTE TAYLOR

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IN THE HIGH-POWER class of airplane engines used for commercial airlines and in the military services, no new models were announced, but improvement in existing models has been continued, accompanied in some cases by appreciable increases in power rating. In the smallest class of engines, on the other hand, namely those used for light planes of approximately 50 hp, a veritable shower of new models was announced during the year. It is to be hoped that there will be enough business in the 50-hp field to support so many producers.

The improved mountings for radial engines under test during the previous year, have been used in several airplanes, and have proved highly successful in reducing the amount of vibration transmitted to the aircraft structure.

An especially important development has been the more or less general adoption of full-feathering propellers for multi-engined transport airplanes. This equipment should increase the safety of twin-engine airplanes considerably, since it improves the performance on one engine and at the same time prevents excessive vibration or actual destruction of an engine which has failed. Considerable interest has been evidenced in propeller blades of compressed wood composition, although aluminum still remains the most popular blade material. Hollow-steel and magnesium blades continue in the experimental stage. During the year much progress has been made in measuring blade stresses under actual flying conditions, and this should result in greater factors of safety for blades of all materials.

The year 1937 came and went without the long-promised arrival of a commercially successful American Diesel engine, and reports from Germany are to the effect that the production of aircraft Diesels in that country was considerably curtailed in favor of spark-ignition types. However, the performance of the *Nordmer* and *Nordsturm* on their transatlantic flights via the Azores was an impressive demonstration of the possibilities of the Diesel engine when used with assisted take-off, and the present long-distance seaplane record is held by a Diesel-engined flying boat. While much progress must still be made before Diesel power plants can compete successfully with spark-ignition types for any but long-distance flights, development work has been, and should be, continued in this field.

Several auxiliary power plants for generating electricity in large airplanes were under development during the year, but apparently none has reached the stage of satisfactory reliability or lightweight. It is interesting to note that most of the larger airplanes designed or built in 1938 called for auxiliary power plants.

A number of high-altitude projects, calling for external superchargers and pressure cabins were reported under development, but no detailed descriptions or test results have yet been published.

IV—Development in Air Transport

By JAMES M. COBURN

NEW YORK UNIVERSITY

THE CREATION of the Civil Aeronautics Authority is unquestionably the outstanding event of the year from the point of view of the air-transport operator.

Since the cancellation of the air-mail contracts several years ago, the air-transport industry has been operating under laws which not only stifled the expenditure of additional capital for expansion but also made existing investments very insecure since no operator had any security in the routes over which he was operating.

INCREASED SAFETY A FEATURE

Technically the last year has seen the completion of many projects which will result in increased safety of operation, increased revenue because of this increased safety, and, in all prob-

ability, decreased cost of operation. The Douglas DC-4 which has been undergoing tests for several months is one of these projects.

Originally conceived by the operators of several of the major air lines together with the engineers of the Douglas company, this plane incorporates the experience gained by the air lines from many thousands of hours of operation with existing equipment. This experience has shown that four motors are desirable in a plane of this size as it is not as exacting in its piloting demands in case of the failure of one motor during the take-off period and is no worse if two motors fail during this period than is a two-motor plane with the failure of one engine. Even though motor failures have been quite infrequent during the take-off period, the possibility of such an occurrence is a great source of pilot strain and consequent fatigue.

In cruising operation the DC-4 can climb to an altitude sufficient to clear any terrain in the United States on any three motors when fully loaded, and with any two stopped it can maintain an altitude which is sufficient to clear terrain on any of the federal airways.

Preliminary estimates of the operating cost of the DC-4 show that the ton-mile cost will be materially lower than existing equipment though not low enough to warrant a sweeping reduction in rates. The large cargo capacity coupled with the fact that the cargo holds may all be utilized to capacity load without disturbing the trim of the plane is an obvious advantage which will result in increased revenue.

INSTRUMENT AIDS TO NAVIGATION

Several radio aids to navigation have passed beyond the purely experimental stage which will result in increased safety of operation as soon as they come into general use.

Direction finding from the ground as a means of checking the position of a plane in flight long has been considered one of the best means of accident prevention. Lack of equipment which would give accurate and reliable information using the communications frequencies of the domestic air lines and which would operate at sufficient speed to handle the traffic which already exists on the airways has been the reason why this safeguard has not come into general use. Now there is available Western Electric equipment which is being installed at certain strategic points that is the answer to most of the previously mentioned disadvantages of this type of equipment if not to all of them.

Another device brought out by Western Electric recently is the terrain clearance indicator. This instrument registers the true height of the plane over the ground and will be of great value in the interests of safety. The indications of this instrument will be important in making instrument landings and it will be useful as well to the navigator since it will indicate the passage over prominent landmarks such as ridges and rivers, thus furnishing him positive position checks which possibly could not be secured with the same accuracy in any other way.

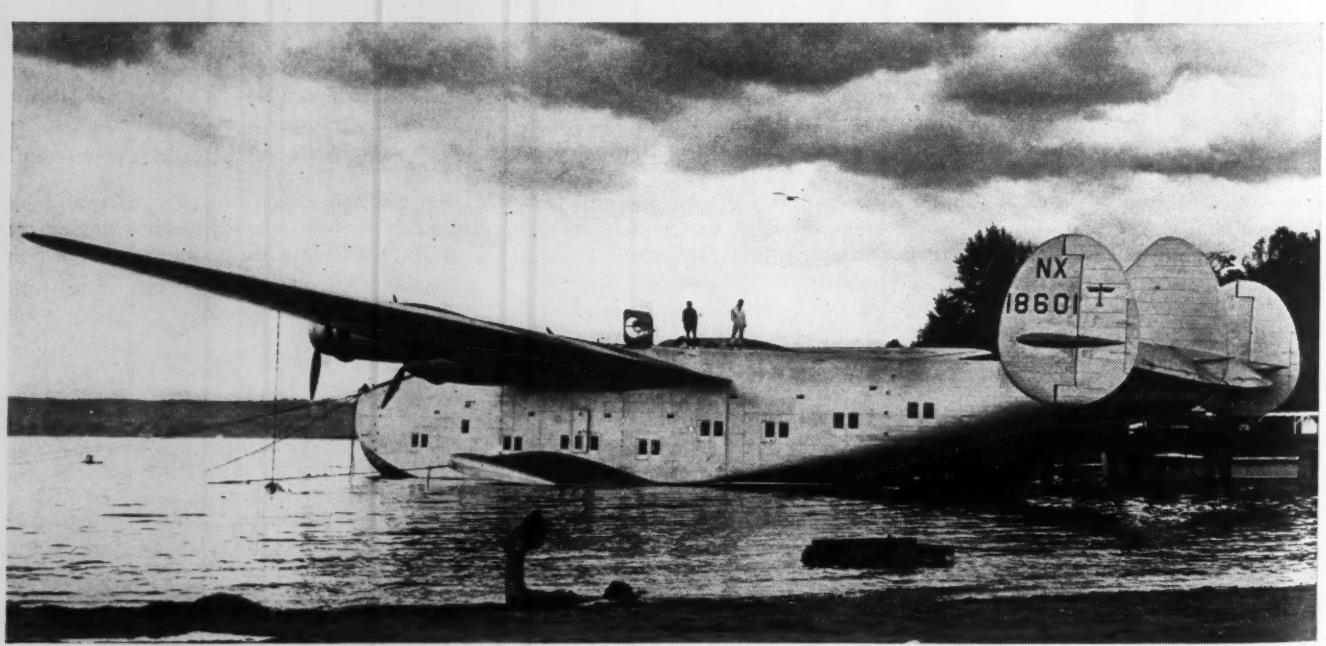
Another radio device of great promise has been revealed by the Sperry Company. This is an automatic radio direction finder for use in the plane. To operate this device the pilot merely tunes his radio to the desired station. An electrical follow-up system causes the loop to rotate until the bearing is secured, indicating it on the pilot's dial. This device has far-reaching possibilities as a means of improving navigation and, consequently, safety.

TRANSOCEANIC AIR LINES

Transoceanic air transport has been marking time during the last year while Pan-American awaits delivery of the new Boeing Clippers. These planes have the capacity and the range to place the United States well in front in the rivalry for trans-atlantic honors.

Competition for Pan-American from another American company is indicated by the entrance into the field of the American Export Air Lines which is a subsidiary of the Export Steamship Lines. This company will operate direct from the United States to Lisbon and from there to Mediterranean ports which are served by the steamship line. This company recently placed an order for a Consolidated flying boat for use in survey and crew-training flights.

The foregoing brief summary of air-transport activities in no way covers the important events of the year. Cooperation between the operating companies and the government agencies is much improved and augurs well for the future so that progress in the next year or two may seem to surpass by far that of any like period in the past.



MODEL 314 BOEING CLIPPER FOR PAN-AMERICAN AIRWAYS

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Day by Day

THREE MONTHS after Munich the Western World finds itself wondering about the effectiveness of the policy of appeasement, holds, in some quarters, the opinion that "peace in our time" is at best an armistice, and continues to enlarge armament and defense programs. To some it becomes apparent that a trial of strength, military or economic or both, between democracies and totalitarian forms of government is in the making, for the propaganda mills grind faster on both sides, filling the press and the ether with attempts at preparing public opinion for mass acceptance of what steps may be taken. Military, economic, social, and moral, in addition to political and national forces are factors in the struggle taking shape. Principles at issue have so effectively permeated the hearts and minds of men that even scientists are forsaking their ivory towers long enough to sign manifestoes declaring their conviction of the necessity of democracy to the best interests of science, and to show concern for the effects of science on the lives and liberties of their fellow men.

Viewing this swelling tide of apprehension and concern for political philosophies, it is hard to assess the strength and persistence of the undercurrent of improved economic conditions that otherwise might justify considerable optimism for the immediate future of this country, at least, as a new year begins. And to these world-wide apprehensions and concerns there must be added the realization that officially this country is still committed to a vast public-spending policy, that its expenditures for relief are a constant reminder of the extent of unemployment, that its budget is still seriously out-of-balance, and that a mounting public debt places it in an unfavorable position for the additional cost of war or even defense programs.

Venture money is still inactive; and the durable-goods industries, recovery in which would be a boon to engineers in particular and assist the country generally toward a realization of that hoped-for eighty billion dollar annual income, have not yet developed desired volume. Indications are not lacking, however, that some of the factors that have retarded capital investment and expenditure may be given needed attention by the Congress.

Interesting announcements, at present without great commercial significance, demonstrate that human intelligence, applied to research, continues to promise developments of a type that have enlarged the circle of human wants in the past. In the face of such announcements faith in the future is sustained. To mention but a few that have been featured in recent press dispatches: Invisible glass, that is, glass with a nonreflecting surface, has been made by Dr. Katherine Blodgett, of the General Electric Company, who utilized a technique consisting of superimposing on the surface successive monomolecular layers of a transparent substance that fails to reflect light. A contemporary announcement by Drs. Cartwright and Turner, of M.I.T., told of accomplishing a similar result by condensing a gas on a glass surface by heating ammonium or sodium fluoride. Dr. C. G. Abbot, of the Smithsonian Institution, has patented an apparatus designed to distill pure water from chemically contaminated water by means of the rays of the sun. At the Richmond meeting of the A.A.A.S., Vladimir K. Zworykin, of the Radio Corporation of America, demonstrated a superelectronic microscope that gives magnifications of one million diameters. In Moscow Prof. Peter Kapitza, former director of the Royal Society's Mond Laboratory, has developed a new method of liquefying gases by a machine of far greater efficiency than that of any so far designed. Engineers of the Bell Telephone Laboratories demonstrated early in January the "Vodor," a machine to create speech, by means of which, through manipulation of an organ-like keyboard and pedal, sounds produced by two vacuum tubes are mixed in such a way as to simulate the human voice.

A.A.A.S.

At Richmond, Va., Dec. 27 to 31, 1938, the American Association for the Advancement of Science, with which The American Society of Mechanical Engineers is associated through Section M (Engineering) and in which individual memberships are held by hundreds of A.S.M.E. members, conducted its annual winter convention. This great meeting of scientists brings together men and women working in many and varied fields, and is the occasion for the annual conventions of numerous scientific societies. It offers a program of general and highly specialized sessions made up of hundreds of scientific papers that attract wide attention in the daily press. As reported frequently in these columns, close relationship with its sister organization, The British Association for the Advancement of Science, has recently been strengthened, and both associations, urged by the trend of the times, have been devoting much attention to the impact of science on society and to the problem of the rôle of science in the modern world. Sir Richard Gregory, editor of *Nature*, of London, was present at the Richmond meeting and delivered one of the general lectures, "Religion in Science." At the meeting of Section M (Engineering) the retiring vice-president of the section, J. M. Barker, member A.S.M.E., delivered an address, "Engineering Planning Vs. Engineering Economy." A. A. Potter, past-president A.S.M.E., is vice-president of the section and F. M. Feiker, member A.S.M.E., is its secretary. The address of Prof. George D. Birkhoff, of Harvard, retiring president of the Association, was entitled "Intuition, Reason, and Faith in Science." The president of the Association is Wesley C. Mitchell, professor of economics, Columbia University. Dr. Walter B. Cannon, of Harvard University, was elected to succeed Professor Mitchell next December. The Annual Sigma Xi Lecture was delivered by W. F. Durand, past-president and honorary member A.S.M.E.

Announcement was made of the formation of a new science organization, the American Association of Science Workers. The purpose of the new association is said to be to promote action among scientists on the relationship between scientific

discoveries and their application to social and economic problems, with a view to preserving democracy. Among the sponsors of the new group is Prof. Harold C. Urey, of Columbia, Nobel prize winner and discoverer of heavy hydrogen.

"Jobs Require Capital"

Under this headline the Toledo Associates recently announced the results of a survey of eight large Toledo industries which last year had 34,870 employees on their pay rolls and 30,782 stockholders on their books. The survey showed over a period of years an average investment of $4219 in machinery, plants, and equipment per employee in 1937. In individual industries this figure was said to be as high as $27,480 per employee, and as low as $1051. In 1929 these same industries had 15,715 employees and 17,910 stockholders. The average investment per stockholder, the survey showed, dropped from $6507 in 1929 to $4780 in 1937. In 1929 the average annual wage was $1690 and in 1937 it was $1521. During this period there was a decline of 10 per cent in average hours worked per week and a change in commodity prices, so that, it is stated, wages have actually advanced about 17 per cent in buying power.

Modernization

A joint survey of the modernization movement reported last fall by the Engineering Societies of New England, Inc., and the New England Council showed that the replacement of machinery by modern equipment lay at the foundation of the trend noted, and was supplemented by rearrangement of production layouts, improved processing methods, and the tuning up of plants generally. New product designs are said to figure in the movement also.

In 12 major groupings of industry, 465 concerns were surveyed. Production costs were considered high by 73 per cent, and 83 per cent charged taxes with chief responsibility; 68 per cent felt that current wage rates are responsible, 48 per cent pointed to high raw-material costs, and 30 per cent believed that inadequate machinery caused the high cost. An average of 60 per cent is trying to obtain increased output per man-hour, 30 per cent redesigned the product to cut material costs, and 15 per cent substituted less costly materials. About 40 per cent have improved materials-handling costs, and 30 per cent have improved machine inspection and maintenance. Sixty per cent have modernized equipment by minor changes or replacement; 25 per cent increased general lighting intensity, and 20 per cent improved special-process lighting. Sixty per cent use depreciation reserves for plant modernization. The survey contains a large number of keyed cases of modernization applying to individual industries.

Steel

Anticipating the proposed visit to this country in October, 1938, of the British Iron and Steel Institute and the Institute of Metals of Great Britain, a visit which the critical international situation of last fall canceled, Arthur G. McKee & Company, of Cleveland, Ohio, prepared an interesting and informative booklet, "A Brief Outline of the Magnitude and Character of the Iron and Steel Industry in the United States." This was issued in spite of the cancellation of the visit by the British engineers and metallurgists. It provides a convenient summary of raw materials, includes maps showing the distribution of reserves and pig-iron and ingot producing capacities, and offers some information regarding finished steel products. The technology of processes is touched on only briefly.

Since the issuance of the booklet the Carnegie-Illinois Steel Corporation's new Irvin works, at Clairton, near Pittsburgh, Pa., was opened on December 15. This $60,000,000 plant is said to have an annual capacity of 600,000 tons of rolled-steel products. One feature of the new plant is an 80-inch "automatic" continuous hot-strip mill. In addition the plant includes a complete cold-reduced tin-plate mill and also a cold-reduced sheet and strip mill. Fifty-one and a half acres are under roof in 17 buildings. The 3750 workers will require a daily pay roll of $30,000. Electricity is used for power and gas for heating.

What Is Engineering?

In reply to a recent telegraphic request to define what is meant by "principles of engineering" as used in the so-called "Model Registration Law," A. G. Christie, president A.S.M.E., couched his personal opinion in the following words: "The principles of engineering are the means of achieving a purpose or producing a result through the application of the laws of mathematics, physics, chemistry, and mechanics, as modified by experience and judgment." Thus is added another "definition" to a long and varied list.

Such terms as "principles of engineering," "engineering," and "engineer" are continuously subjected to definition. They are, like Robert Southey's Russian general's name, "a name we all know by sight very well, but a name we can neither pronounce nor spell!" But we can try.

Recently a definition of "engineer," written by Karl T. Compton, appeared, with comment, in MECHANICAL ENGINEERING. One of our British contemporaries noted it and expressed a preference for the century-old definition by Tredgold that appears in the charter of the Institution of Civil Engineers: "The art of directing the great sources of power in nature for the use and convenience of man."

This definition, as everyone will agree, is sufficiently broad to take in almost anything, including engineering, but it was prefaced, in the charter, by the words "the profession of a Civil Engineer, being, etc ," and was followed up by specific mention of the kinds of work civil engineers were engaged in in the early part of the nineteenth century.

Although the definition in the I.C.E. charter is generally attributed to Tredgold, his name does not appear in connection with it. The Institution was established in 1818 and was incorporated June 3, 1828, and the charter is found in the first volume of the Proceedings, 1837–1841, published in London in 1846. Tredgold's connection with the definition in the charter is set forth in the address of Charles Hatton Gregory, president of the Institution on January 14, 1868, in which he said:

"But reference to our past records has brought to light one document which I venture now to lay before you, believing that it must be interesting to every engineer, from its authorship and from its bearing on the history of the Institution.

"At a meeting of the Council, held on December 29, 1827, it was

'Resolved—That Mr. Tredgold be written to, requesting him to define the objects of the Institution of Civil Engineers, and to give a description of what a Civil Engineer is, in order that this description and these objects may be embodied in a Petition to the Attorney General, in application for a Charter.'

"At the following meeting of Council, on January 4th, 1828, the Secretary read the communication received from Mr. Tredgold, which is thus inserted in the minutes: Description of a Civil Engineer, by Thomas Tredgold, Hon. M. Inst.C.E."

The text of the famous Tredgold memorandum follows, and will repay anyone who wishes to read it in volume 27, 1867–

1868, pages 180 et seq., of the Proceedings, I.C.E. It commences:

Civil Engineering is the art of directing the great sources of power in Nature for the use and convenience of man; being that practical application of the most important principles of natural philosophy which has, in a considerable degree, realized the anticipations of Bacon, and changed the aspect and state of affairs in the whole world. The most important object of Civil Engineering is to improve the means of production and of traffic in States, both for external and internal trade. It is applied in the construction and management of roads, bridges, railroads, aqueducts, canals, river navigation, docks, and storehouses, for the convenience of internal intercourse and exchange; and in the construction of harbors, moles, breakwaters and lighthouses; and in the navigation by artificial power for the purposes of commerce.

Besides these great objects of individual and national interests, it is applied to the protection of property, where natural powers are the sources of injury, as by embankments for the defence of tracts of country from the encroachments of the sea, or the overflowing of rivers; it also directs the means of applying streams and rivers to use, either as powers to work machines, or as supplies for the use of cities and towns, or for irrigation; as well as the means of removing noxious accumulations, as by the drainage of towns and districts to prevent the formation of malaria, and secure the public health. This is, however, only a brief sketch of the objects of Civil Engineering, the real extent to which it may be applied is limited only by the progress of science; its scope and utility will be increased with every discovery in philosophy, and its resources with every invention in mechanical or chemical art, since its bounds are unlimited, and equally so must be the researches of its professors.

The remainder of the memorandum shows how "one of the great bases on which the practice of civil engineering is founded is the science of hydraulics," and illustrates how the engineer employs it in many ways, "for the use and convenience of man."

Honors

Among the names that appeared on King George's New Year's honors list were a few which engineers will note with interest and gratification. Especially satisfactory to members of The American Society of Mechanical Engineers was the knighthood conferred on Stephen J. Pigott, managing director of the John Brown Shipyard, Clydebank, Scotland, builders of the *Queen Mary* and *Queen Elizabeth*. Announcement of the award of the 1938 A.S.M.E. Medal to Mr. Pigott was made on Honors Night at the 1938 Annual Meeting. George M. Patterson, chief naval architect of the Cunard-White Star Line, and Donald M. Skiffington, shipyard director at the John Brown plant, were rewarded by titles of the Commander of the Order of the British Empire. The Order of the British Empire medal for "meritorious service" was awarded to Tommy Rankin, foreman of riveters who worked on the *Queen Mary*.

Sir James Jeans, scientist and expounder of science to laymen, and Admiral of the Fleet Lord Chatfield, former First Sea Lord, generally credited with having brought the British Navy to its present peak of efficiency, received the highest honors, the Order of Merit. A baronetcy was conferred on Sir Peter Rylands, president of the Iron, Steel Wire Manufacturers Association.

"Ersatz" Engineers

It has been known for some time that Germany has been especially concerned about its supply of engineers for its *ersatz* and military program. In a recent dispatch it was announced by the Associated Press that Field Marshall William Goering, as head of the four-year plan for economic self-sufficiency, has ordered that courses in the highest engineering and mining schools be reduced from four to three years; those in technical academies are to be cut to two years.

Humanitarian Engineer

Not from duties in the field of engineering but in that of humanitarianism in which one of the world's greatest engineering leaders, Herbert Hoover, served so brilliantly and effectively the refugees and unfortunates of the World War, D. Robert Yarnall, member A.S.M.E., industrialist and engineer, recently returned to this country with two other members of the Friends Service Committee after having secured Nazi approval of a threefold program for removing Jews to other countries. Associated with Mr. Yarnall on the committee were its leader, Dr. Rufus M. Jones, of Haverford College, and George A. Walton, headmaster of a Friends school at Newtown, Pa. It was reported that under the plan the Quakers would: Set up camps outside Germany where emigrants can be cared for until they can be sent to new homes; with the cooperation of the German government send out as soon as possible 150,000 of the younger Jews to new colonies in other countries; and cooperate with these 150,000 to have them take their families out of Germany.

Fermi

Prof. Enrico Fermi, 1938 winner of the Nobel prize in physics, has left Italy and has recently arrived in New York where, according to George B. Pegram, member A.S.M.E., he will serve at Columbia University for an indefinite period as visiting professor of theoretical physics. Professor Fermi lectured at Columbia in 1936, following the announcement in 1934 of his discovery of the ninety-third element, which he obtained by bombarding the nucleus of uranium with neutrons. Readers of MECHANICAL ENGINEERING will recall his name in connection with an article, "The Fermi-Dirac Statistical Theory of Gas Degeneration" by Prof. Vladimir Karapetoff, that appeared in the April, May, and June issues, 1933.

D. C. Jackson

To a list of distinguished scientists and engineers whose "meritorious achievement in electrical science, electrical engineering, or the electrical arts" has been recognized by the American Institute of Electrical Engineers by the award of the Edison Medal has been added the name of Dugald C. Jackson, member A.S.M.E., a past-president of the Institute, professor emeritus of electrical engineering at the Massachusetts Institute of Technology, and electrical engineer in the fields of generation and distribution of electric power.

Graduated from Pennsylvania State College in civil engineering in 1885, Dr. Jackson entered upon a study of electrical engineering at Cornell, 1885–1887, and began his professional career in the infant electric light and power industry in 1887. In 1891 he formed a consulting engineering firm with his brother, W. B. Jackson, and in the same year began, at the University of Wisconsin, his career as one of the country's best known teachers of electrical engineering. Engineering practice and teaching engaged his attention concurrently from that time on; he left Wisconsin for M.I.T. in 1907 and organized the firm of Jackson and Moreland in 1919. From M.I.T. he retired in 1935, and with the consulting engineering firm he remained as senior partner until 1930.

For his achievements as engineer and teacher he has received many high honors; to both branches of his dual profession he has made notable contributions, utilizing the experiences and

expanding practices in one to enrich what he communicated to student engineers in the other. A forceful and energizing character with qualities of leadership and inspiration that appeal not only to colleagues and practitioners but to young men as well, he has been a constructive participant in the growth of engineering practice and teaching, in engineering and educational societies, and in the broadening development of the engineering profession. Lively in his interest in men and affairs and in nonengineering fields as well as those collateral with engineering, he has acquired a philosophical and historical perspective of engineering which he embodied in a series of lectures, "Engineering's Part in the Development of Civilization," published in 1938 in MECHANICAL ENGINEERING and soon to be issued in book form.

R. I. Rees

To one who knew Robert I. Rees only during the latter years of his life when he came most intimately in contact with engineering education, engineering societies, and the Engineers' Council for Professional Development, the recently published booklet, "Robert Irwin Rees—An Appreciation," is a welcome revelation. This beautifully written and printed biographic memorial, published by the National Occupational Conference, to which General Rees made such a substantial contribution of his time, energy, and interest, reveals the rich quality of the man and the principal events of his career, particularly those of his life before he left military for civil service. To Raymond G. Fuller, who prepared the booklet, engineers and educators are indeed in debt, for with sympathetic insight and a dignity that does credit to General Rees's quiet modesty, a career and a beloved personality are convincingly portrayed. Although it cannot bring back the man himself, it does, in its own way, preserve his spirit, and by many of the General's friends it will be referred to, when courage is at the low ebb, "for the strengthening of hearts."

Robert Ridgway

Shortly before Christmas, 1938, there died, en route from Chicago to New York, Robert Ridgway, civil engineer, of whom neither members of his chosen profession nor laymen ever uttered words except of high praise and warm affection. No engineering college can point to his name among those of its graduates. He learned from life and nature by exercising the intelligence and energy with which he was so richly endowed and by association with men whose names were internationally known and others who labored nameless in field and drafting room. His achievements, embodied in some of the greatest engineering works of the times, touched the lives of millions through the metropolitan water supplies and rapid-transit lines without which a great city cannot exist. Retired from his civic post by reason of that rule which attempts to lay aside men of a certain age, he continued to devote much of the time that might have been spent in well-earned leisure in continuing to pour forth from the inexhaustible fountain of his knowledge, judgment, and experience, the fructifying waters of his wisdom. Thus, refusing to become inactive, even when the demands of health might have justified withdrawal from professional life, he passed from one peak of achievement to another, and even at the end he was at one such summit, for that end came, suddenly and peacefully for him, while he was returning to New York from the ground-breaking ceremonies of the Chicago subway, an enterprise in which he had been engaged. Modesty was his habit; no self-acclaim is necessary where the works so loudly proclaim genius. He understood nature's laws; and with that understanding he beguiled Nature herself to serve with him his fellow men. But best of all, he held his fellow men in warm affection and esteem, encouraged and aided youth, and left the world in a richer condition than that in which he found it.

Fritz Funk

On October 14, 1938, a few months prior to his eighty-first birthday, died Fritz Funk, who, with C. E. L. Brown and W. Boveri, established in 1891 the Swiss engineering and manufacturing firm of Brown, Boveri and Co. Funk, the commercial and financial genius of the firm, handled its business affairs from the time of its organization, through the years of expansion when it branched out with the establishment of many plants in many nations, the trying period of the World War, the vicissitudes of depression and prosperity following the war, and the keen competition of postwar conditions, and ultimately became president of the board of directors. Although he resigned as president in 1934 he remained, until 1937, in a consultative capacity in the board of management, and even after 1937 he still took part in meetings of the board of directors. Nor were his services limited to those of a financial and commercial expert, for he early devoted himself to labor problems when, in 1900, he became sole manager. Credit is given to him for the peaceable labor relations of the company and the whole Swiss machinery and metallurgical industry. It is said that he was one of the prime movers in establishing workers' welfare funds, later transformed into employee pension and workmen's assistance funds, and in the building of workmen's and employees' dwelling houses. In the midst of his business duties he found time to serve certain official and semiofficial institutions in the Canton of Aargau. On his seventieth birthday he was honored with a degree from the University of Basel and in 1916 he was made an honorary citizen of Baden.

Hosea Webster

To many of us who think of ourselves as still young the death of Hosea Webster in his eightieth year came as a shock. He was one of those vigorous characters that, if they cannot be called perpetually young, are at least thought of as being perpetually mature. The years dealt kindly with his tall and stalwart figure, symbolic of the rugged individualism of his Connecticut forbears, one of whom served that colony as governor in 1656. Nor had age whitened to any appreciable extent the heavy locks of dark hair that crowned his strong-featured countenance.

Few men, indeed probably none, ever scrutinized the professional records of as many members of The American Society of Mechanical Engineers as had he, for he served on the Membership Committee, later known as the Committee on Admissions, during the period of the Society's greatest growth. In 1930, in recognition of his twenty-five years of activity on this committee, he was awarded a "life membership for distinguished service," the only membership of this character on the Society's rolls.

Hosea Webster's professional life covered practically the entire history of the A.S.M.E. Following graduation from Cornell in 1880, in the course of science and letters, with a degree of B.S., he received the degree of M.S. from the same institution in 1881, and from there went to Stevens Institute of Technology where the degree of M.E. was granted him in 1882. His professional career began that same year, with Henry R. Worthington Hydraulic Works, which he served for two years in New York and until 1894 in Chicago as sales manager of

HOSEA WEBSTER

that office. He joined the A.S.M.E. the year after his graduation from Stevens, and on his application for membership appear the names of two of that institution's distinguished faculty members, Henry Morton, and Robert Henry Thurston, first president of the A.S.M.E.

In 1894 Mr. Webster returned to New York as sales manager of the New York office of the Worthington firm, and in 1897 he began his long years of service with the Babcock & Wilcox Co., which terminated with his retirement from the general sales managership in 1933. He died on January 2, 1939, at his winter home in Coral Gables, Fla. His brother, William Reuben Webster, chairman of the board of the Bridgeport Brass Company, who is also a member of the A.S.M.E., survives him, as do also two sisters, his second wife, a step son, and two sons by his first wife.

Antimonopoly Investigation

AMERICAN ENGINEERING COUNCIL

MANY NEWS statements have been made of the voluminous testimony presented on Dec. 1, 1938, at the opening of the hearings of the Temporary National Economic Committee, says an article in the December issue of the *AEC Bulletin*, official organ of the American Engineering Council, but an attempt is made in the article to select the material of interest to the engineering profession on basic industrial and economic conditions as seen by the principal speakers, Isador Lubin, Commissioner of Labor Statistics, Department of Labor, Willard Thorp, adviser on economic studies, Department of Commerce, and Leon Henderson, executive secretary, T.N.E.C. The summary follows.

PURPOSE AND FUNCTION OF THE COMMITTEE

In the introductory remarks, Senator O'Mahoney, chairman of the committee, stated that the purpose of the committee was to make a comprehensive study of concentration of industry, of industrial price policies, and of existing government policies, and the effect of these upon commerce and trade. The function of the committee, he said, was merely to study the facts objectively and impartially and to make report of its findings and suggest constructive recommendations.

The preliminary statements by Drs. Lubin, Thorp, and Henderson were undertaken because the committee felt that it was desirable that there should be presented first an analysis of the facts of the performance of our economic system as they have appeared to the various government agencies which deal with problems affecting national commerce and industry.

STATEMENT BY DR. LUBIN

The significant points made by Dr. Lubin deserve a large measure of attention and careful scrutiny. Factually and laboriously, through a series of some fifty statistical charts, he presented his analysis of the problem of the breakdown of our economy from the angle of production, employment, and pay roll.

Performance and Needs of Citizens. The first point he made was that the performance of our economy must be measured in terms of "meeting the requirements of our citizens." To maintain our standards of living, the output of commodities and service produced must be increased, at least proportionately to the growth of population.

Growth of Population. The rate of growth of our population has been steadily decreasing since 1880. Between 1850 and 1880 our population doubled; between 1880 and 1910 it increased 80 per cent, and between 1910 and 1940 it will have increased 43 per cent. The estimated increase in population between 1940 and 1960 will be less than ten per cent.

Annual Percentage Rate of Increase. In terms of annual increase the average rate of increase was about two and one third per cent a year between 1870 and 1900. From 1900 to 1920 the average was one and two thirds per cent a year; from 1920 to 1935 it was slightly over one per cent a year. The estimated rate of increase for the period from 1940 to 1960 will be only one half of one per cent per year.

Comparison—Population and Production. Goods and services available for a population at any given time are measured in terms of national income.

Income Defined. The national income is defined by Dr. Lubin as "the sum total of all goods—industrial and agricultural—and services produced in the United States in terms of dollars."

Decline in National Income From 1930. Between 1920 and 1929 the average annual income was 55 per cent greater than it was in the preceding ten years. From 1930 to 1938 there was a decline in the national income. Between 1920 and 1929 the average per year was $69,000,000,000, while between 1930 and 1938 it declined to $50,000,000,000.

Average Individual Income. Between 1910 and 1919 the average individual income was $420 per person; between 1920 and 1929 it was $606. An increase of 40 per cent in the average individual income was opposed to the increase of 55 per cent in the total national income, "the difference between the two was due to the fact that population was increasing."

By means of graphic presentation, Dr. Lubin showed that "there was an almost uninterrupted increase from 1850 to 1929 both in total national income and in per-capita income. After 1929, however, both . . . dropped off sharply. . . Even if allowance is made for price changes, the decline in national income during the depression was impressive."

The essential thing to notice, however, is the fact that

output of commodities and services increased faster than the increase in population. "There were more and more goods available for our citizens despite the fact that the number of these citizens was increasing."

Between 1930 and 1938 the average individual income—"the amount of goods and service available to our people as individuals"—declined to an average of $397 per year. This average is considerably less than it had been in the decade from 1910 to 1919 and the decade 1920 to 1929. For 1932 the average individual income was $320; for 1937, $404; and the estimate for 1938, $472.

Comparison With Other Countries. Still, despite this tremendous drop that took place over the last nine years, "we are in a far better position than England, Germany, France, and Sweden. According to available data, the average income in 1934 and 1935 in the United States was $432, as compared to $401 in England, $345 in Germany, $321 in Sweden, and $267 in France.

Income Losses During Depression. Dr. Lubin stated that the losses to labor, to agriculture, and to investors added together—assuming that we maintain the level of 1929—amounts to $133,000,000,000, which compares with a national income in 1929 of $80,000,000,000. This is a cumulative loss. In other words, "if our economic system had functioned as effectively in the nine years from 1930 to 1938 as it did in 1929, the people of this country would have had 132 billion dollars more real income than they actually had. The American people lost approximately one and one half times as much goods and services as was produced in 1929."

Industrial Production per Capita. Taking 1923–1925 period as 100, the increasing physical volume of industrial production, omitting agriculture, was from about 100 in 1899 to 167 in 1910 whereas the per-capita output of our industries increased from 100 to 135. That is, "the amount of goods available to individuals of this country per capita was 35 per cent greater, at least in terms of products of mines and factories, than it had been in 1899."

Production Output in Relation to Growth of Population Since the Civil War. From 1863–1865 to 1929 output of factories and mines increased much more rapidly than population, with the exception of a few scattered years. From 1870 to 1900 the total industrial production multiplied five times; per-capita output increased two and a half times. From 1900 to 1929 the output increased threefold, and nearly doubled on a per-capita basis. In the nine years, 1930–1938, industrial production has averaged nearly 15 per cent smaller than it did in the preceding nine years.

Durable Goods in Our Economy. Throughout the 50 years, 1879–1929, durable goods have increased in importance as compared with nondurable goods. This was due largely to the increase in consumers' expenditures on such commodities as automobiles, refrigerators, etc. "It is important," said Dr. Lubin, "that we know the value of the durable-goods industries." Between 1879–1929 the importance of durable-goods industries, which contributed 31 per cent of our output in 1879, had risen to the point where they are producing 44 per cent—almost half of our output. Since 1929 there has been a sharper drop in the output of these industries than in the nondurable-goods, industries. This, of course, is due to the sharp decrease in consumers' expenditures on such commodities, as compared with the expenditures on nondurable necessities like food and clothing during a depression.

The curtailment of production in the durable-goods industries increased unemployment more rapidly than did the "service industries." Durable-goods industries, thus, are one of the major parts or segments in our economy where the breakdown is greatest. And, as Senator O'Mahoney said, "to take up the slack in unemployment, then, it is necessary to stimulate the durable-goods industries."

After showing by means of charts, how our economy failed to function in various segments, Dr. Lubin stated: "To get this economic security and to get this rise in standard of living, I think two things are involved. It means more and more production. We have just got to produce more and more, and of course it has got to be balanced in some way so that you won't be overproducing one type of commodity and underproducing another type of commodity.

"Secondly, and equally as important, if not more important, is some equitable distribution of that income which will permit us to absorb these products of agriculture and of industry. In other words, a distribution of that national income which will keep all of these goods moving, and we have got to produce more and more to have a higher standard of living.

"You can't have a higher standard of living unless you produce more and more goods. With fewer goods to go around you can't live as well, taking the nation as a whole, as when there are more goods. This equitable distribution in turn means—I will put it this way: This increased standard of living and this rising standard of living means definitely that our national income must go up from $61,000,000,000 this year, or approximately $62,000,000,000, to at least $75,000,000,000, if not $80,000,000,000, if our standard of living for the country as a whole is going to be as good as it was in 1929, taking an increasing population into consideration; you have more people to feed, clothe, entertain, and keep healthy, but with our present population, if there were to be available in the country as much goods per capita and as much service as there was in 1929, we would have to increase our national income, as I say, from $61,000,000,000 or $62,000,000,000 to something between $75,000,000,000 and $80,000,000,000."

STATEMENT BY DR. THORP

Dr. Thorp began his testimony by stating that Dr. Lubin had showed the results of the performance of our economic machine and that he would try to show how the economic machine was operating. An examination of the machinery through which and by which these processes take place "is basic because that is where economic problems come from. Our failure to maintain the past rate of advance in the standard of living is certainly not due to any lack of management, ability, capital, labor, or natural resources."

Significance of Analysis. The analysis is significant because our economic machine, he stated, "is exceedingly complicated with so many varying units. Variations appear because of differences in products, process, location, market, and habits and practices, which have become the custom in this or that industry or trade." Furthermore, these variations within the economic structure are continually changing. Then, too, the nature and character of the economic structure is continually changing.

Factors in Change. Technological change and advance "create new industries and destroy long-established ones," causing change and temporary dislocation in the functioning process of our economy. "The initiative of business men, individually and collectively" or what economists call "innovation," is a constant factor and "creator of change," while too much inertia on the other hand may also cause a maladjustment. Some situations have sufficient public importance to warrant government intervention. The impact of these factors has changed greatly our economic pattern in recent years, both within the structure itself and in the relationship of government to industry."

United States Business Population. Starting with a chart "United States Business Population," Dr. Thorp pointed out

that there has been a steady increase in the growth of business enterprises. In 1900 there were about 1,200,000 business enterprises. "There has been a steady increase in the business population, halted temporarily in 1919, but rising to a peak in 1929 when there were 2,213,000 enterprises." Business mortality is great, but it is far from being dead. "Each day there are 1300 new enterprises opened, but 1150 disappear."

Length of Survival of Business Enterprises, Poughkeepsie, New York, 1843–1926, not Counting Changes in Proprietorship. Over half of business concerns established in Poughkeepsie between 1843–1926 went out of business before their fourth year. One fifth . . . were in business 10 years or more . . . ; less than 10 per cent remained . . . longer than 20 years. Wholesale concerns survived longest. More than three fifths remained in business over three years; one third remained for over 10, and about one sixth remained for over 20 years. Service enterprises had the shortest life—only 8.1 per cent of total existing enterprises remained over 20 years.

"In the manufacturing field 53 out of each one hundred lasted over three years; 25 out of each one hundred lasted ten years; and 12.6 out of each one hundred lasted 20 years."

In the retail concerns "less than half survived three years; less than 22 per cent, more than ten years; and less than 10 per cent, more than 20 years."

In the crafts, including such as barbers and tailors, the survival was lower, 44.9 over three years; 20.9 over 10 years; and 9.2 over 20 years.

Restaurants and such had the shortest length of life; 44.9 over three years; 18.8 over ten years; and 8.1 over 20 years. "Taking all types of business, 46.9 per cent lasted more than three years; 21.4 per cent more than ten years; and 9.7 per cent twenty years or more."

Causes of Discontinuance of Old and New Enterprises. Dr. Thorp pointed out that the factors which make enterprises continue or discontinue are: The competence or incompetence of management; whether the opportunity presented the new enterprise was good or bad; the forces of competition; and the credit available or needed. The urge to enter business is great.

Difficulty of Entering Fields of Business. There are, however, certain industries, he said, "in which it is virtually impossible for a new enterprise to appear"—natural resources, for example—"because existing reserves are already generally held." There are also cases where "patent situations may be an effective bar to entering a particular type of business activity." Another effective bar for a new enterprise to enter a field of business is the case "where outlets are controlled, or there has been built up such a consumer acceptance by existing enterprises that it is difficult . . . for a new enterprise to break into the market."

Type and Character of Enterprise—Corporation and Partnership—Their Number. Dr. Thorp then turned to an analysis of the growth of the number of corporations and partnerships since 1910. By means of a chart, "number of corporations and partnerships," he showed that there has been a steady increase in the number of corporations since that period. The chart indicates that partnership organizations have not been so significant a factor in the growth of our industrial development. "The almost uninterrupted increase in the number of corporations reflects the growing tendency toward large-scale business. Between 1909 and 1936, the number of corporate enterprises more than doubled." Though there has been a rise in partnerships from 1917 to 1924, successive decline took place until 1934. There were about 84,000 fewer partnerships in existence in 1936 than in 1924.

The growth of corporations has reached "a point of somewhere around 550,000 corporations at the present time"—an increase of 94 per cent since 1910. The number of corporations, he said, "have increased just about twice as fast as our business population." He also pointed out the fact that "of these corporations, about 10 per cent are inactive."

Importance of Corporate Activity in 1937. He also showed the increasing importance of corporate activities by branches of industry in 1937, which measures the concentration of corporate wealth. "The relationship of corporate to noncorporate income constitutes an important measure of concentration in various branches of industry. In 1937 over 90 per cent of the entire business of manufacture was done by corporations and this branch of industry contributed about one fourth of the total national income produced this year. It is estimated that practically all electric light and power, manufactured gas, and communication companies are corporately owned. The agricultural industry, on the other hand, is conducted principally by individuals." One hundred per cent of electric light and power, manufactured gas, and communication companies are corporately owned; 96 in mining; 92 in manufacturing; 89 in transportation; 84 in finance; 58 in trade; 58 in government; 30 in service; and 33 in miscellaneous; 7 in agriculture.

Employee Distribution. Taking another view of the business population and its activities, Dr. Thorp showed, by a chart, the distribution of employees and employers by size of business concerns. The distribution is as follows: 50.7 per cent of employers, 3 or less employees, and 4.0 per cent of all employees; 0.2 per cent of employers (3511), 1000 employees and over, 32.0 per cent of all employees; 0.01 of employers (195), 10,000 employees and over, 12.3 per cent of all employees.

Size of Corporations by Assets in 1935. In 1935, Dr. Thorp showed, 1.4 per cent of the assets of all corporations were held by 55 per cent of the corporations; the assets amounted to less than $500 apiece; two tenths of one per cent of all corporations, on the other hand, held about 52 per cent of all corporate assets. These were corporations having over $50,000,000 each.

Assets of Large Manufacturing Industries, 1935. "Large corporations dominate the tobacco industry, total assets of corporations with assets over $5,000,000 accounting for 91.7 per cent of assets of all corporations, but representing only 5.9 per cent of the number of corporations. Assets of chemical and allied products corporations are also largely owned by big corporations, the $5,000,000 and over group contributing over 85.7 per cent of total assets of all corporations in this industry. In the liquor and beverage field, the large corporation is of minor importance, only 28.6 per cent of the total assets being owned by corporations with assets over $5,000,000.

"Transportation and other public utilities are dominated by large corporations. Over 92 per cent of the total assets are owned by corporations with assets of $5,000,000 or more. Finance ranks next to transportation, over three fourths of all assets fall into the $5,000,000 and over. At the other extreme is the construction industry with slightly more than 25 per cent of the total assets owned by large corporations."

Antitrust Laws and Big Business. Dr. Thorp stated his opinion that the antitrust laws brought about much of the development of big business. "Through the process of interpretation, we have arrived at a state of law where five enterprises, each of which, let us say, represents ten per cent of an industry, cannot have collective action with regard to prices or markets or allocation of production without running afoul of the antitrust laws. That becomes a conspiracy in restraint of trade. If, however, these five enterprises . . . merge in a single enterprise, . . . that single enterprise has no problem of conspiracy or combination. It is only a single enterprise."

STATEMENT BY DR. HENDERSON

Dr. Henderson brought to focus what has been stated by Dr. Lubin and Dr. Thorp. He emphasized the complexities of the

problem. "We are left," he said, "with a tremendous sense of appreciation for the degree of coordination which still remains in our economic system that can produce sixty-two billion dollars of national income this year, and about sixty-nine billion dollars last year. But appreciation gives way to bewilderment and perplexity when we remember losses take $120 billion of wages and salaries, $38 billion of farm income, and $20 billion of dividends in the last nine years. In human terms the losses are measured by the millions of unemployed."

Strength of Our Economy. Dr. Henderson emphasized that our system, "which even at the low level is ahead of the estimates of the per capita available in other countries, is still a pretty vigorous system. This is due to the basic characteristics of our system with its emphasis on the reliance on the individual."

Basis of American System. Our American economic system derives its strength and vitality because of its basic philosophy upon which our economic institutions are built. Our economic system has had characteristics in common with other capitalistic systems, "but it also had special traits which distinguish it from others." What are the special traits which constituted the American competitive capitalistic system?

"The American system has emphasized the dignity of the individual, his resourcefulness, and has had essential reliance on the ability of individuals, in free association, to design affirmatively the main forms and directions of life.

"Its basic legal institutions have included private property and freedom of contract, with the collateral assumption of approximate equality of bargaining power.

"It has assumed acceptance of minimum but workable rules of law, democratically determined, under which each individual, in pursuing his personal self-interest, would also serve the logical interest of the community.

"It has rested on a belief that there should be no long-term restriction of the international flow of goods, or the freedom of the individual to make economic decisions at his own risk.

"It has placed its faith in the function of price and the market mechanism as the best possible forces for the allocation of the resources and the determination of distributive shares to worker, investor, owner, and risktaker alike. It has had a concept to the free market as one which no buyer or seller could dominate.

"Implicit, but less well-defined, have been assumptions of mobility of labor and capital, almost unlimited land, and natural resources, that the economy and its population would expand indefinitely, and that all possible savings could be readily employed in natural expansion of facilities for serving consumers.

"Government, it has been thought, should intervene mainly to compel observance of working rules.

"Taken together, these assumptions, as I read them, have constituted the American competitive capitalistic system."

But the dynamic changes of our economic and industrial growth have affected our basic assumption. The important changes that have occurred in our economy, which are to be considered, are the passing of the frontier, the rise of "collective effort" and of "revulsion against risk," with the decline of the competitive process. These changes in our economy brought in their trail the insistent need for a modification of structure and function of our economic institutions. Changes in the process of production, changes in type and size of enterprises, changes in financing enterprises, changes in selling practices, "change, change, change," resulted in bringing about the malfunctioning of our economic system.

No Line of Attack. Dr. Henderson pointed out that he expected more to indicate the seriousness of the situation, the complexity of it, and the absence of any clear line of attack" on these problems. "The over-all question," said Dr. Henderson, "seems to be, why have we not had full employment and full utilization of our . . . resources? Specific questions, however, are more directly pointed at the target."

Status of Competition. "What is the present status of competition? Has it lessened? Is the lack of self-adjustment of the economy due, wholly or in part, to decline in competition?

"Can this country rely in the future on competition as the mainspring of its economic system? If so, what changes are necessary in public and private policy to make competition effective? If not, what are the alternative organizing forces available? Is the choice necessarily between full competition and full planning?

"To what degree and in what areas has competition as the regulating force been set aside?

"Are prevailing price and production policies implicitly based upon vigorous price competition? To what extent is competition through development of the product a satisfactory substitute for price competition?

"What are the wastes in the distributive system?

"What devices, mechanisms, policies, and organizational forms have been consciously utilized to defeat competition?

"In what particulars are the antitrust laws inadequate?"

Future of Competition. "Is the lack of competition always due to conscious efforts, or are impersonal elements and forces also responsible?

"Can economic effort be divided into monopoly and competition? Are both sometimes present? Does overcompetition exist?

"What part has concentration played in the decline of competition? What part has size played? Is concentration on the increase? Is concentration an inevitable consequence of a developing industrial organization? Of the corporate form? What are proper standards for corporations doing interstate business?

"Does concentration affect adversely or favorably the distribution of income? The efficiency of output? Is economic activity affected by the character of income distribution?

"What results are expected to flow from competition? Can tests be constructed in terms of these expected results for measurement of accomplishment of industrial organizations? Could such tests be used to measure effectiveness of economic organization in cases where competition has legally been modified or set aside? Can these be applied to organizations of workers?

"How flexible is the economy? Where is it inflexible? What standards of desirability of flexibility can be framed?"

Lag in New Investments? "Has new investment lagged? Is this likely to continue? Has the forward drive of the American economy stopped?

"Have we witnessed the end of our dynamic mass production, lower price, more employment policy? Are we in for stagnation or decline? What is the proper function of government in periods of underinvestment? Is government debt different from personal debt? Under what set of economic conditions can savings be absorbed? What is the influence of the present rate of return on investment?

"Are our liberties endangered by the growth of private control? Is there a relation between collectivism in private industry and collectivism in government? How can the dignity and importance of the individual be enhanced by choices of economic policies? Should the government intervene to afford the individual business man a better status in competition?

"Which segments of the economy have managed their prices and production? In which have these possibilities meant fewer jobs? What effects have patents had upon expansion of production?

"What has been the record of success of government intervention in the various economic processes here and abroad?"

Plans of Committee—Main Lines of Study. Dr. Henderson con-

cluded with an outline of the main lines of study to be undertaken by the committee:

A Concentration and control. Facts. Its causes. Over-all and specific industry studies. In natural resources, insurance, financial institutions, transportation, communications, distribution, etc. Patterns of control. Effect on competition, as shown by government purchasing, price behavior, opportunities for entry by individuals and small enterprises, new investment, and expansion. As related to costs, technical progress, labor policy, individual firm stability

B Price system and price policies. Patterns. Changes from competitive assumptions. Effect on general level of trade, and on demand for specific products. On long-time profits, consumption. Maintenance of prices vs. maintenance of employment. Patterns and standards of desirability in rigid and flexible prices. The problem of balance

C Effect of governmental policies
- (1) Specific policies: as named by resolution
  - *a* Taxation—burden on industries, relation to expansion, and lack of new investment. As stimulus to activity
  - *b* Patents, pools, specific abuses. Place in competitive enterprise. Litigation—costs, duration, effect on small enterpriser. Delays in granting procedure. Division of ownership—individuals and corporations. Utilization and suppression. As stimulus to activity. Key patents. Place in technological displacement
  - *c* Adjustment of purchasing power to 1926 price level
- (2) Government policies not specifically named by resolution
  - *a* Compensatory fiscal policies
  - *b* Governmental intervention; corporations, loan agencies, etc.
  - *c* Foreign trade, reciprocal trade agreements
  - *d* Agricultural program
  - *e* Housing
  - *f* Governmental regulation. Lessons to be drawn from experience of I.C.C. Coal Commission, S.E.C., Federal Power Commission, Maritime Commission, Labor Board, Wage and Hour, Walsh-Healy, Federal Communication, etc.
  - *g* Social security
  - *h* Results of other legislative committee studies; munitions, holding companies, etc.

D Bureau of Industrial Economics

E Socially and economically harmful competition

F Improvement of antitrust policy and procedure
- (1) Codification of law as to restraints of trade, etc.
- (2) Procedural study—investigation, enforcement, adjudicative processes
- (3) Studies of foreign experience, relations of government, and business abroad

G National standards for corporations

H Mergers, interlocking relationships, industrial, utility, and bank-holding companies, investment trusts

I Insurance companies. Organization, practices, importance in economy, investment policies, etc.

J Corporate practices. Existing forms of business organization, trade associations, alternative forms

K Distribution. Marketing laws

L Credit mechanisms for small enterprises

M Over-all economic data and special studies. Consumer credit. Labor racketeering. Break-even points. Depreciation and cost accounting. Debt growth.

Atom Smashers

JOURNAL OF APPLIED PHYSICS

LORD RUTHERFORD'S discovery in 1919 of the disintegration of atoms of nitrogen under bombardment by natural radioactive alpha particles from radium, opened up a new field of exploration within the heart of the atom. The alpha rays from the rare radium are simply high-speed helium

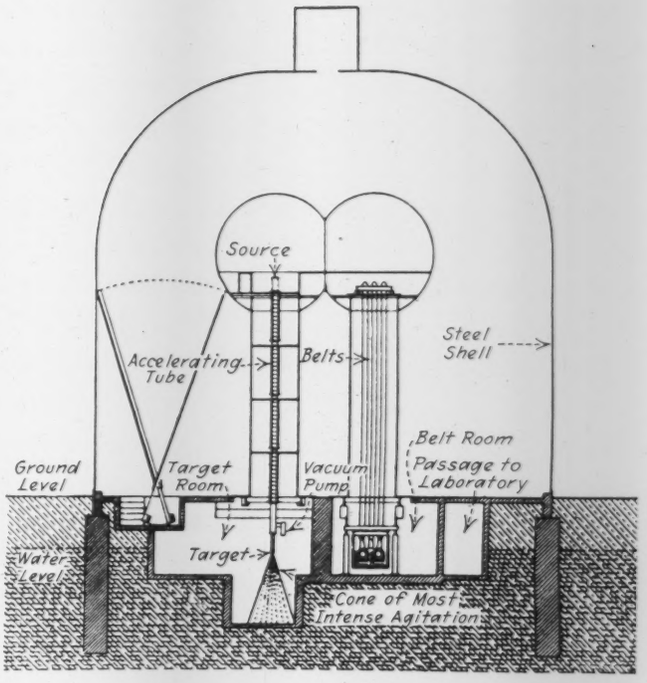


FIG. 1 DIAGRAM OF THE M.I.T. VAN DE GRAAFF ELECTROSTATIC GENERATOR

ions. These ions may be produced at will in gases by an electric discharge, but to use them in place of alpha rays requires means for accelerating them to high speed.

It was found that this could be done by a high direct voltage, which was first produced by transformers and rectifiers, later by a high-voltage electrostatic generator, and now by a highly ingenious cyclotron which produces a very high ion speed without the use of high voltage or direct voltage. Experiments with these machines have not only been in the direction of elucidating the nucleus, but many by-products of the elucidation have shown themselves to be of untold value to biologists, biochemists, medical doctors, and engineers. From the engineering viewpoint, these experiments may be the preliminary steps of the eventual discovery of a new form of mechanical power. To justify this statement it is only necessary to point out that in the atomic nucleus reside all the positive electricity, much of the negative electricity, and by far the greater part of the mass and energy in the universe.

As described in two articles in the November, 1938, issue of the *Journal of Applied Physics*, the methods for accelerating charged particles to high energies which have received the most successful development for nuclear transmutations are those of direct high voltage by means of belt generators as developed by Robert J. Van de Graaff and the cyclotron method due to Ernest O. Lawrence. A brief description of the two methods, as summarized from the two articles, is herewith presented.

The generator developed by Van de Graaff in its simplest form consists of a hollow metal sphere mounted on insulating supports and charged by a fabric belt conveying negative or positive electricity from earth potential and depositing it within the interior of the sphere. A generator of this type, recently completed at M.I.T. (see Fig. 1), has produced voltages of about 2.4 million volts positive and 2.7 million volts negative under adverse conditions of humidity with belt currents of several milliamperes. Eventually, it is expected that 10 million volts will be possible.

In the M.I.T. installation an electron beam is focused down

a vacuum tube at about 2 million electron volts. As shown in Fig. 1, the terminals are set up in contact to obtain a single-terminal generator with belts in one column and a vacuum tube in the other, resulting in safety, precision, and speed of operation. The generator is well suited for nuclear research on resonance disintegration and with multiply charged ions. In addition, yield calculations suggest its usefulness as a neutron generator in the production of artificial radioactivity. At the

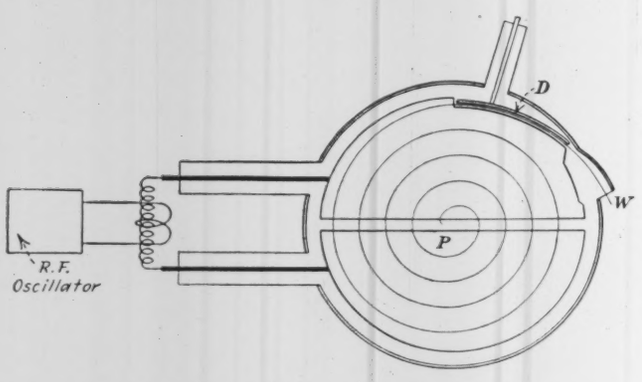


FIG. 2 A SCHEMATIC SECTION OF THE VACUUM CHAMBER OF A CYCLOTRON

Westinghouse Research Laboratories, a similar generator, but with a single sphere surrounded by a pressure vessel, is under construction.

Recently, there was developed a method for replacing the belts by blowing an air stream containing small particles of charged siliceous material from the ground to the high-voltage electrode. This is accomplished by passing the particle-laden air through an ionizing region, as is done in the Cottrell method of electrical smoke precipitation, and removing this charge by a metal collector at the high-voltage terminal.

In the Lawrence cyclotron, ions are generated from some gas in a circular vacuum chamber between two flat, hollow, roughly semicircular electrodes, supplied with high-frequency voltage from an oscillator. A strong transverse field from a powerful electromagnet, coacting with the oscillating electrostatic field of the electrodes, causes the ions to spiral out from the center of the chamber, receiving two accelerations for every turn of the spiral, until they emerge through the periphery of the chamber with enormously high velocity, such as that which would be produced by the older methods with 5 or 10 million volts.

Fig. 2 shows a schematic section of the vacuum chamber of a cyclotron which is placed between the poles of the large electromagnet, imagined here to be above and below the plane of the paper. After a high vacuum is created in the chamber, a small quantity of some gas is allowed to flow into the vacuum chamber and out through the pump line. As a stream of electrons ionizes part of the gas at *P*, each ion which is formed is accelerated in a spiral path, as shown in the drawing, until it reaches the region in which a transverse electrical field is maintained by a plate *D* held at a high negative potential. This deflecting field, together with the gradient of the magnetic field near the periphery of the magnetic field, is sufficient to direct the ions into a target chamber *W*.

Besides learning about the action of electrons, protons, deutrons, alpha particles, and other ions, some no larger than one million-millionth part of a centimeter in diameter, scientists are using atom smashers to treat cancerous growths in human beings, to study problems of metabolism, rate of circulation and interconversion of body fluids, and to investigate reaction rates, photosynthesis, and other problems.

Why Torsion Tests?

AMERICAN SOCIETY FOR TESTING MATERIALS

FAILURES under simple tension are probably rarer than ruptures under torsional and shear stresses or under a combination of tensile and compressive stresses. Static tensile stresses never cause failure through fatigue, whereas alternate torsional stresses, or repeated twisting stresses do, argued Albert Sauveur, professor emeritus, Harvard University, in the Edgar Marburg Lecture read by him before the American Society for Testing Materials at Atlantic City, June 29, 1938. Dr. Sauveur claimed the following advantages for the torsion test: (1) Simplicity of manipulation, (2) low cost of torsion-testing machine, (3) low cost of preparation of test bars, (4) adaptability to high-temperature testing, (5) possibility of reverse twisting, (6) possible adaptability to determination of creep, (7) possibility of testing at will under constant speed of twisting or under constant speed of loading, and (8) determination of properties unrevealed by the tension test.

A brief description of the parts and operation of a torsion machine, as illustrated in Fig. 3, follows. The main essentials of the machine are the torque wheel *A*, the specimen *B*, and the pendulum *C*. When motor driven the torque is applied by gear *D*.

Torque wheel *A*, exactly 8 in. in diameter, is rigidly fastened to the main shaft F_1, F_2. E_1 and E_2 are housings, each of which holds a double ball bearing on which the shaft turns. By using the two bearings E_1 and E_2 bending of the specimen is averted when the load is applied. A $^1/_3$-hp, 250-v, d-c motor

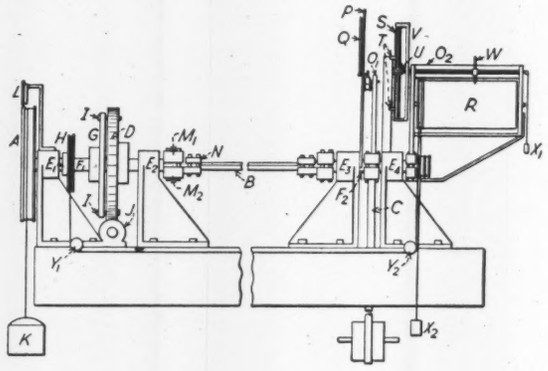


FIG. 3 THE TORSION MACHINE

turns the worm gear *J* which activates gear *D*. Gear *D* is not fastened to the shaft and so in order that gear *D* turn the shaft, it is bolted to plate *G* by two bolts *I*. Plate *G* in turn is keyed to the shaft. For manual loading bolts *I* are removed, permitting the shaft to turn freely in gear *D*. The load is applied by hanging weight *K* from the torque wheel. For continuous loading water is run into bucket *K* at a uniform rate. The torque wheel turns whether the loading is by motor or by hand, and the twist is read in tenths of degrees on vernier *L*. Blocks M_1, M_2, and *N* constitute the chucks for holding the specimen which is held fast by bolting plate *N* to chuck M_2.

The twisting of the bar turns shaft F_2 which turns on two double ball bearings mounted in housing E_3 and E_4. Rigidly fastened to shaft F_2 is also the pendulum and the recording arms O_1 and O_2. As the load is applied arm O_1 turns with the pendulum, and with the aid of a connecting pin, a toothed bar, and pinion, and suitable guide wheels, needle *Q* is caused to move so that it becomes possible to take torque readings directly from dial *P*.

One of the features of the machine is the device for obtaining

automatic torque-twist diagrams. Suitable graph paper is mounted on drum R which turns freely on its axis. Regardless of the amount of twisting in the specimen itself, the applied torque lifts the pendulum a definite amount which causes frame O_2 to move similar to O_1. The turning of the frame O_2 causes pinion S to roll in the rack T. Pinion S always remains in a vertical position as its holder V is allowed to pivot freely on frame O_2. Worm gear U which has the recording pen W attached to it by means of a cord, is integral with pinion S. Any movement of gear S pulls the recording pen toward it in proportion to the torque applied or very nearly so. The cord is kept taut by means of the small weight X_1. This weight pulls the pen back in recording yield points and rupture in which cases the rate of torque application becomes negative.

The twist is recorded as that turning through which shaft F_1 goes. Wheel H is attached to shaft F_1 with a setscrew and as this wheel turns it lets out the cord which twists drum R with the aid of pulley guides Y_1, Y_2, and others which can be seen to good advantage in Fig. 3. Weight X_2 is really the means of turning drum R as it keeps the cord taut when it is released from wheel H.

Present-Day Rubber Applications

A.S.M.E. FALL MEETING, PROVIDENCE, R. I.

AN ANALYSIS of the rubber industry discloses that few fundamental limitations exist as to what can be produced of rubber and rubber-like synthetics, or as to the size of the articles and the range of their use. The production problems involved can be quite satisfactorily solved if, of course, the economic aspects are properly taken into consideration, states E. G. Kimmich, development engineer, The Goodyear Tire and Rubber Co., in a paper on "Production Processes and Problems in the Rubber Industry," presented at the Fall Meeting of the A.S.M.E. in Providence, R. I., Oct. 5–7, 1938.

In his detailed description of the processes used today, Mr. Kimmich tells how adhesion of hard rubber to metal surfaces has been utilized for many years by affixing a layer of hard rubber next to the metal surface and then applying layers of progressively softer rubber over the hard rubber. By such means, good adhesions were obtained but the method was relatively expensive and not always applicable.

Improved cements are now available which give remarkably good adhesions of soft-rubber compounds directly to metal surfaces. But the most startling development has been the recent widespread utilization of the adhesion of soft rubber to brass. By carefully controlling the brass composition and using cements adapted for the purpose, adhesions can be obtained which have a bond greater than the cohesion of the strongest rubber. By brass-plating steel under properly controlled conditions, it is possible to get adhesion to steel articles with such strength and reliability that the method has opened up a wide field of applications. An example of such application is the almost universal use of steel-backed rubber mountings for automobile engines.

The lining of pipes and tanks to resist various types of corrosion and abrasion has become an important item in the rubber industry. Before applying the covering, the metal surfaces are usually sandblasted and cemented. The rubber lining is calendered and applied by hand "tailoring" each individual job. Vulcanization is accomplished by filling the tank with water and then heating with steam. However, when possible, the entire tank is put in a steam heater so that higher-temperature steam and higher pressure can be applied to give a firmer bond and a shorter vulcanizing period.

Rubber or synthetic covered rolls for the paper, steel, printing, and other industries, are prepared by a similar process and then ground to the desired diameter. Accuracy of grinding, closely controlled hardness, and selection of proper compound or stock, are of major importance.

Using rubber as a base, many related materials have been produced by various chemical and physical treatments. Under these conditions, the rubber loses many of its usual characteristics but gains other important properties. Since most of the processes for making these items are held in secrecy due to the recent nature of this type of development, it is not feasible, therefore, to discuss the methods by which such articles are produced, but various plastics, paint resins, and film material (see MECHANICAL ENGINEERING, Oct., 1938, page 773) are being commercially made of such rubber derivatives.

In consideration of the rate at which new processes, new compounds, new synthetics, and new uses have developed, the rubber industry has come to feel that the enormous growth in the past is but an indication of much greater growth in the future.

Hydraulic Machine Tools

1938 ANNUAL MEETING, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

HYDRAULIC UNITS have been successfully applied to shapers and planers by Paul S. Jackson and his associates, according to a description of such installations by him at the 1938 Annual Meeting of The American Society of Mechanical Engineers, New York, Dec. 5, 1938. A hydraulically operated shaper to outward appearances looks like any conventional shaper, but there is a complete absence of bull gear, rocker arm, transmission, clutch, etc. Selection of ram speeds is secured by a standard variable-delivery valve mounted on the side of the column, which gives an infinite variation between maximum and minimum motions.

In order to get a direct comparison of the benefit of hydraulic drive over a mechanical type, a recording device with a revolving-drum driven at a peripheral speed of 168 in. per min was made. This device was mounted on the shaper table and, with a pencil in the tool post, made it possible to trace a ram-action diagram which is shown in Fig. 4. In both cases the cutting speed was 40 ft per min and the stroke 10 in. As shown in the diagram, due to the dead-center point in a crank-

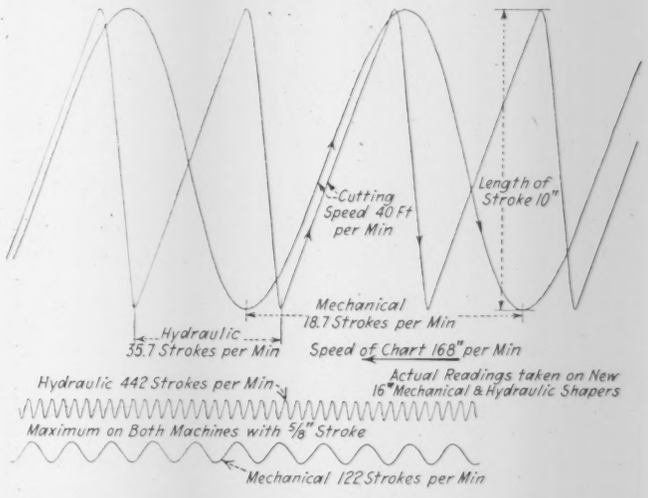

Cutting Speed 40 Ft per Min
Length of Stroke 10"
Mechanical 18.7 Strokes per Min
Hydraulic 35.7 Strokes per Min
Speed of Chart 168" per Min
Hydraulic 442 Strokes per Min
Actual Readings taken on New 16" Mechanical & Hydraulic Shapers
Maximum on Both Machines with 5/8" Stroke
Mechanical 122 Strokes per Min

FIG. 4 HYDRAULIC-SHAPER RAM-ACTION DIAGRAM

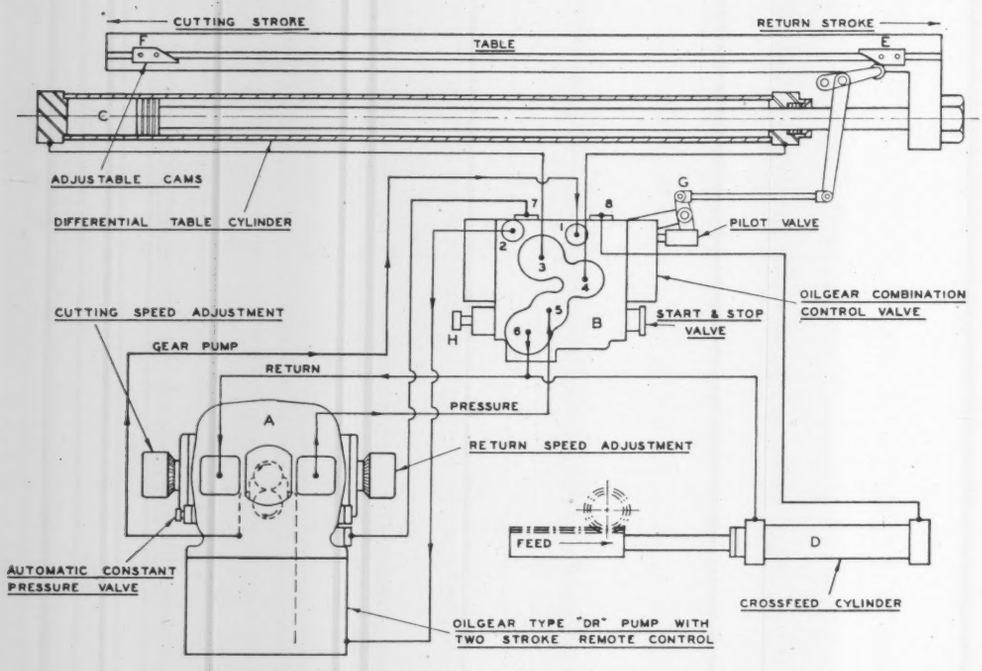


FIG. 5 HYDRAULIC-PLANER CIRCUIT DIAGRAM

shaper mechanism, considerable delay occurs at both ends of the stroke, resulting in only 18.7 strokes per min in the mechanical type against 35.7 strokes per min in the hydraulic drive. Another feature the diagram discloses is the constant cutting speed throughout the entire tool travel. Hydraulic shapers are not limited by a transmission to a selected number of strokes per min; an operator, knowing the material being cut and the tool to be used, selects the cutting speed desired throughout the entire job regardless of how many times it may be necessary to change the stroke length or position. For that reason it is possible when running on short strokes to get many more strokes than are obtainable in a mechanical transmission. The diagram shows 442 strokes per min against 122 on a mechanical type. Strokes up to 600 per min are possible with this type of hydraulic drive.

A schematic diagram of the circuit employed in a planer is shown in Fig. 5. Standard variable-delivery pumps are used. In the actual installation, the pump, motor, and tank are mounted in the bed and the cylinder is directly under the table in the rear half of the bed with its piston rod extending forward to a bracket which is attached to the front end of the table.

With this construction, the oil on the cutting stroke enters the front end of the cylinder on the piston-rod side, pulling the table through its cut with the piston rod in tension. The oil exhausted on the other side of the piston under a low back pressure is applied against the full area of the piston, and enters the suction side of the pump, thus assisting its rotation in a manner similar to the operation of a hydraulic motor.

The radial piston pump is used on the planer because of its variable delivery which makes it possible to secure any cutting speed. On the return stroke, the pump automatically shifts to full delivery for full-speed return.

In conclusion the author says that the general trend of machine-tool design for years to come will follow the use and application of hydraulic units not only to shapers, planers, and slotters, but also to drills, honers, broaching machines, milling machines, lathes, grinders, and practically all metal-removing machines.

House Construction Research

NATIONAL BUREAU OF STANDARDS

TO THE report issued in June and noted on page 771 of our October issue, the National Bureau of Standards has added two more of the series on Building Materials and Structures, BMS 2, "Methods of Determining the Structural Properties of Low-Cost Housing Constructions," by Herbert L. Whittemore and Ambrose H. Stang, and BMS 3, "Suitability of Fiber Insulating Lath as a Plaster Base," by Lansing S. Wells and D. C. Smith.

The first of these reports, BMS 2, describes methods used by the National Bureau of Standards to determine the structural properties of elements of a low-cost house; that is, structural properties of wall specimens under compressive, transverse, concentrated, impact, and racking loads; of partition specimens under impact and concentrated loads; of floor specimens under transverse, concentrated, and impact loads; and of roof specimens and transverse and concentrated loads. A graphic method of presenting the results is also described. Tests carried out according to the methods described represent an attempt to develop a standard procedure for evaluating the structural properties of house construction. Tests of new construction according to the new uniform procedure as to size of specimen and test methods, along with similar tests on conventional constructions, are expected to form a more reasonable basis for judging the value of new construction than any method now available. Ultimately, says Lyman J. Briggs, director, in a foreword, such performances may find their way into building codes to replace present requirements, which specify details of sizes of members for use in conventional types of construction.

In order to cooperate with industry to the fullest extent, specimens of structural elements are solicited for inclusion in the Bureau's program. The specimens will be tested without expense to the sponsor. A report giving results of the tests on his construction will first be submitted to the sponsor for his criticism and comments. These will be given careful consideration in the preparation of the final report, which will then be published by the Bureau and made available to the public.

The Bureau neither approves nor disapproves any construction.

The second report, BMS 3, concerns an investigation of the properties of wall and plasterboards and the suitability of fiber insulating boards as a plaster base. Such properties as density, strength (flexural and tensile), and linear changes accompanying changes in relative humidity and wetting and drying were studied in the investigation. The boards were mounted on steel frames and the extent of buckling resulting from changes in relative humidity was determined. Methods of successful application of plaster on insulating lath were determined by experiments, and resulted in the definite recommendation that only quick-setting strong plaster be used and that the thickness of the plaster be not less than one-half inch.

Reducing Woodworking Wastes

A.S.M.E. WOOD INDUSTRIES DIVISION MEETING, HIGH POINT, N. C.

LUMBER purchases seldom constitute less than 40 per cent of all manufacturing costs and, sometimes, are as high as 70 per cent. Therefore, any reduction of waste in rough-dimensioning operations leads to a saving not only in material but also in labor. Methods of making this possible were described by H. M. Sutton, member A.S.M.E., at a joint meeting of the Wood Industries Division of the Society and the Southern Furniture Manufacturers' Association at High Point, N. C., Sept. 21–23, 1938.

From his varied experience in improving present practices and developing new and better procedures to effect cost reduction in woodworking industries, Mr. Sutton gave the following outline on how to uncover dimensioning wastes and reduce them:

1 Establish dependable weekly records of production and waste by kinds, thicknesses, and grades of lumber used, since these differences mean different wastes. For the most effective control of waste and labor costs, it has been found advisable to set up the lumber, production, and labor records, as in Table 1.

TABLE 1

Mill-room inventory (start)	ooo
Plus lumber intake	oooo
Total	oooo
Deduct mill inventory (end)	ooo
	oooo
Deduct production in board feet—"clearance"	oooo
Waste	ooo

2 Check all cutting costs, or the dimensions on manufacturing instructions, and improve the latter. (See Fig. 6.)

3 Determine the average waste percentage over one or more years past.

4 Analyze pay rolls to find past average cost of rough-dimensioning operations.

5 Study suitability of kinds and grades of lumber to needs and cost of product. In several instances a more thorough knowledge of waste factors has demonstrated that at least a portion of a given product can be made at a lower net cost by the use of less firsts and seconds and more no. 1 common.

6 Standardize yard and kiln practice to reduce losses due to poor inspection, improper piling, and faulty drying methods.

7 Check machine equipment for rough-dimensioning (and also for subsequent operations) to make sure that it is in good operating condition and will do both high-speed and accurate work.

8 Study waste at rough-dimensioning operations. The basic ones, of course, are due to defects, end waste, edging waste, and saw kerfs. Investigation has shown, that in addition to these four, there are nineteen other sources of lumber waste that can be corrected.

9 Learn ability and methods of individual operatives in getting most from lumber.

10 Analyze machine, assembly, and lumber-storage wastes.

11 Determine allowable waste limits by classes of product.

12 Establish production rates for all rough-dimensioning operations through time and motion studies.

13 Combine these waste standards and production rates into a group bonus plan; placing emphasis on reducing waste.

14 Work with supervisors and operators to demonstrate that real savings can be made, and gain their cooperation to perpetuate and improve the new methods.

Length
Longest dimension plus 1/2"—Use next higher 1/8" if not even 8ths.

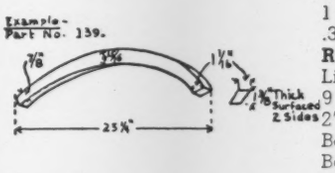
Exceptions
Fin. Length plus 0 where rough cut-off length is accurate enough without later end trimming.
Fin. Length plus 3/4" on Linderman stock 14" wide or less.
Fin. Length plus 1" on Linderman stock over 14" wide.

Width—
Ripping Width (at ripsaws or Lindermans)
Greatest finished width of net block plus 1/4".
Use next higher 1/16th if not even 16ths.
Bandsaw Width—Single pieces same as for ripping. Nest size made up of size required for ripping 1 pc., plus net widest width of each additional piece nested, plus 1/4" for each additional piece nested. Maximum width of slabs from Linderman = 24" for straight sawing, or 16" to 18" for tilt table.
Exception—If piece is routed to rip, stick and shape:—
Rough Width = greatest finished width plus 1/4" (rip to stick) plus 1/8" (sticker to shaper) = total of 3/8" allowance.
Exception—Rough size = finished size, where rough width only is required and one ripping or bandsawing makes finished piece.

Thickness— Finished Thickness	Not Dressed Add Allowance	Dress 1 side Add Allowance	Dress 2 Sides Add Allowance
1" or less	0	1/8"	3/16"
Over 1"	0	3/16"	1/4"

Use next highest rough thickness of the following Standard Thicknesses:—5/8", 3/4", 1", 1 1/4", 1 1/2", 1 3/4", 2", 2 1/2", 3", 3 1/2", 4".

Exceptions—Be sure variety specified can be bought in thickness desired. If not, use next thickness or specify other wood.



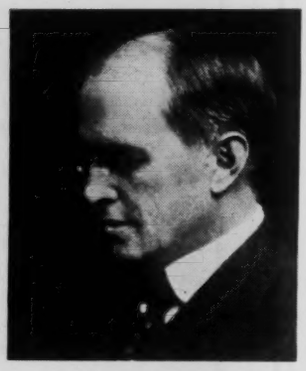
Finished Dimensions—
1 3/8 x 1 1/16 x 25 1/4 = .372 Bd. ft.
Rough Size—
Linderman 16" wide makes 9 pieces.
2" x 16" x 25 3/4" = 5.730 Bd. ft. or 1 piece = .637 Bd. ft.

FIG. 6 STANDARD ALLOWANCES TO ADD TO FINISHED SIZES TO GIVE ROUGH CUTTING SIZES OF LUMBER

By utilizing the points just outlined, it has been possible to locate and correct avoidable losses in a woodworking plant as much as 10 per cent of its annual lumber bill. It has been a source of saving for manufacturers of packing boxes, auto bodies, toys, furniture, office equipment, chairs, architectural woodwork, store fixtures, laboratory equipment, school furniture, and other wood products.

A.S.M.E. HONORS AND AWARDS

IV—The Holley Medal



G. I. ROCKWOOD

GEORGE I. ROCKWOOD, member of The American Society of Mechanical Engineers since 1891, vice-president of the Society in 1924 and 1925, and president of the Rockwood Sprinkler Company of Massachusetts until his recent retirement, proposed as early as 1920, that the Society establish an award in the form of a gold medal to be given periodically to an engineer for distinguished service in engineering and science. President Edward S. Carman and the Council accepted his suggestion and voted to have the first award made on Dec. 7, 1921, to Hjalmar G. Carlson, even though the medal was not endowed or ready at that time.

In 1923, Council received a communication from Mr. Rockwood in which he offered to provide the gold medal, and it was voted "that the Council place on record its sincere appreciation of the gift by Mr. Rockwood."

For the time being the award was called The Great Achievement Gold Medal, but a little later, at the request of Mr. Rockwood, it was named the Holley Medal in honor of Alexander Lyman Holley, chairman of the meeting on Feb. 16, 1880, at which preliminary plans for the organization of The American Society of Mechanical Engineers were discussed by a group of prominent mechanical engineers of that day. His untimely death in 1882 cut short a career closely allied with the history of Bessemer steel manufacture in the United States, and prevented Mr. Holley from being one of the Society's early presidents.

With the same thoroughness which helped him become one of the most successful engineers of his day, Mr. Rockwood immediately commissioned Desmond Fitzgerald and John Wilson to make a design for the Holley Medal and had a gold medal for Mr. Carlson, the first recipient, struck off from the steel dies. Then, to provide for future awards, Mr. Rockwood gave the Society $6000 as an endowment for the Holley Medal.

RULES GOVERNING AWARD

The Board of Honors and Awards of the Society in considering the nominations of candidates by members and others, governs itself in its selection, subject to final approval by Council, by the following broad and general rules laid down by Mr. Rockwood in his deed of gift:

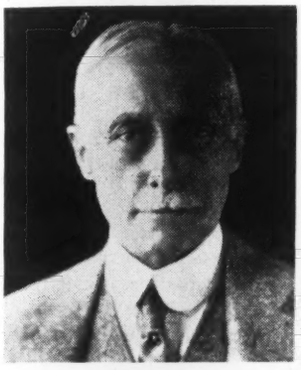
> The Holley Medal shall be bestowed only on one who by some great and unique act of genius of an engineering nature has accomplished a great and timely public benefit.
>
> In judging the merits of any candidate for this award no limitation shall arise out of the degree of his education, his membership or lack of membership in any society or organization, or the circumstances of his employment or official position. Attention shall be concentrated on the brilliance and benefit of his act—not on the man.
>
> The achievement should be of such public importance as to be worthy of the gratitude of the nation and call forth the admiration of engineers. It should, therefore, be reserved for those meriting the very highest honor within the gift of the mechanical-engineering profession
>
> When the Board of Honors and Awards has reached unanimously a tentative and informal decision in favor of a candidate for this award, his name and a statement of the achievement for which it is deemed properly in accord with the conditions herein to present him with the award shall be . . . submitted to the Council for its approval. The favorable action of the Council by at least two thirds of those present shall decree the award.
>
> When awarded the Medal shall be accompanied by an engrossed certificate . . . bearing the seal of the Society . . . and signed by the President and Secretary.
>
> . . . If in the opinion of the Board of Honors and Awards the interest on the fund of $6000, added to the principal, should accumulate to a sum greater than an amount sufficient to provide an award to a single recipient annually, then the excess income may, at the discretion of the Board, be used for the award of other prizes.

MEDALISTS

HJALMAR GOTFRIED CARLSON was awarded the first Holley Medal on Dec. 7, 1921, "for his inventions and processes which made possible the timely production of drawn-steel booster casings for artillery ammunition thereby aiding victory in the World War," but he did not actually receive the medal until 1924. Born in Sweden in 1878, he came to the United States in 1891. After serving his apprenticeship as a machinist and mechanic, he worked for the Worcester Pressed Steel Company until he resigned to assist in the organization of the Worcester Fire Extinguisher Company which later became the Rockwood Sprinkler Company. He grew with the company and, at the time of his being awarded the Holley Medal, was general superintendent and mechanical engineer. During the War, when his company turned to the manufacture of ordnance material, he rendered valuable service to the United States Government because of his invention and part in the production of 20,000,000 Mark III drawn-steel casings used principally as a component of 75-mm high-explosive shells and of gas shells and bombs.

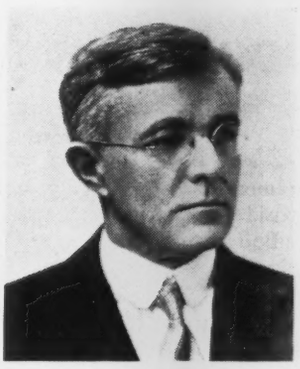
ELMER AMBROSE SPERRY received the 1927 Holley Medal on May 16, 1928, "for achievements that have contributed greatly to the progress of civilization and for many inventions that have advanced the naval arts, including the gyroscopic compass, which has freed navigation from the dangers of a fluctuating magnetic compass." Born in Cortland, New York, Dr. Sperry began his long career as an inventor at the age of nineteen, with the building of his first dynamo. There followed inventions in electrochemistry, electric railways and automobiles, and the first electric mining machinery. About 1916, he produced his high-intensity-arc searchlight, five times as powerful as any before it. However, his most widely known inventions relate to the gyroscope. Out of his work in this province came the gyrocompass, the gyrostabilizer, the gyropilot, and the detector car for detecting irregularities in railroad tracks. To these outstanding developments must be added hundreds of lesser inventions—his U. S. patents alone numbering 380—all of which made their contribution to the modern scheme of things. Nevertheless, he still found time to serve the A.S.M.E. in many capacities, being president in 1929.

BARON CHUZABURO SHIBA was awarded the 1929 Holley Medal on April 8, 1930, during the visit of members of the Society to Tokyo for the World Engineering Congress, "for his contributions to knowledge through fundamental research, including the field of aerodynamics, by the development of ultra-rapid kinematographic methods." Baron Shiba was professor

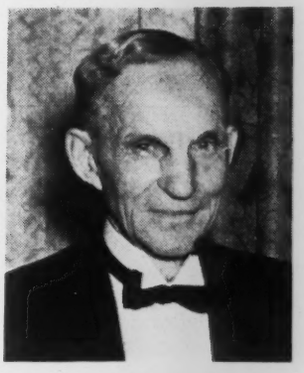


E. A. SPERRY

CHUZABURO SHIBA



IRVING LANGMUIR



HENRY FORD

F. G. COTTRELL

THE HOLLEY MEDAL

FRANCIS HODGKINSON

of mechanical engineering at the Tokyo Imperial University, a member of the House of Peers, vice-president of the World Engineering Congress, director of the Aeronautic Research Institute in Tokyo, and a world authority on marine engineering and aeronautics, in which latter field, by his combination of mechanics and optics, he developed a new technique in the study of air turbulence by which the phenomena, ordinarily invisible to the eye and occurring within intervals of less than 1/40,000 of a second, could be viewed and recorded and then studied quantitatively at leisure.

IRVING LANGMUIR received the 1934 Holley Medal on June 20, 1935, "for his contributions to science and engineering, including the development of gas-filled incandescent lamps, thoriated filament for thermionic emission, atomic-hydrogen welding, phase-control operation of the thyratron tube, and fundamental research in oil films." After a brief period as an instructor at Stevens Institute of Technology, he joined the staff of the research laboratory of the General Electric Company as a research scientist in 1909, and, today, is associate director of the laboratory. Among many awards he has received is the 1932 Nobel Prize in Chemistry for work on surface chemistry.

HENRY FORD was recipient of the 1936 Holley Medal on May 20, 1937, "for revolutionary influence through invention and practice on transportation and on mass-production methods in manufacturing." Mr. Ford, a member of the A.S.M.E., through his inventions and theories of transportation, his world-flung industries, and exceptional efficiency in manufacturing and mass production, all of which are engineering accomplishments, has made an outstanding contribution to the present generation of peoples in all civilized countries. His record and achievements began as a boy on his father's farm and continued until he now is, and has been since 1901 when he organized the Ford Motor Company, the inspiring genius, able administrator, and philanthropic executive of the largest privately owned industry in the United States. His record and achievements place him in the forefront of American engineers.

FREDERICK GARDNER COTTRELL was awarded the 1937 Holley Medal "for preeminent public service—the invention of electric precipitation—advancement of the science of gas liquefaction—gifts for engineering research." He is noted for his work in the field of electric precipitation covering processes and apparatus for separating and collecting particles of one liquid suspended in another liquid, or suspended particles from gaseous bodies, for the purification of gases, for abatement of smoke, fumes and dust, and other forms of electrical precipitation. The rights in these "Cottrell Patents" were vested in a corporation called Research Associates, formed in 1912, and since engaged in the business of acquiring patents by purchase or otherwise and developing and administering them, the net earnings being contributed to the Smithsonian Institution, or other scientific institutions and societies, selected by the Board of Directors, to enable them to conduct technical and scientific investigation, research, and experimentation.

FRANCIS HODGKINSON was given the 1938 Holley Medal "for meritorious services in the development of the steam turbine." Born in England in 1867, apprenticed at 15, a graduate of the shops, he entered the employ of the Charles A. Parsons Company in 1885. Sent to the United States in 1896 with the Parsons patents which had been acquired by the Westinghouse Company, he stayed and organized the turbine department and was its chief engineer for many years, and later consulting engineer until his retirement a few years ago. During these 40 years his genius as a designer, inventor, and constructor has been evident to all. The number of his patents exceeds 100, while the turbine horsepower built under his charge has expanded to almost astronomical proportions. He has served the A.S.M.E. as a member of the Power Test Code Committee since 1918, being chairman of it in 1938.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquires must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretation of this Committee formulated at the meeting of December 2, 1938, which was subsequently approved by the Council.

CASE No. 575

(Annulled)

CASE No. 683

(Annulled)

CASE No. 867

(*Special Ruling*)

Inquiry: Par. P-11 permits the use of seamless alloy steel pipe to Specification S-34 for pressure parts of superheaters. In the absence of specifications for seamless alloy boiler tubes, an opinion is requested as to the acceptability of such tubes for superheater pressure parts provided the physical requirements of Specification S-34 for ferritic steels are complied with, and the chemical requirements are either in accordance with one of the ferritic grades of steel covered by Specification S-34, or are substantially within the range of ferritic steels of that specification, with variations only in silicon, chromium, or molybdenum content.

Reply: It is the opinion of the Committee that in the absence of suitable A.S.T.M. specifications, alloy steel tubes as described may be considered as tentatively meeting the requirements of the code for superheater pressure parts until such specifications are available, provided:

(*1*) The dimensions, tolerances, and marking requirements of Specifications S-17, S-40, A.S.T.M. Specifications A 209-38T (to be designated as Specification S-48), or A.S.T.M. Specifications A 210-38T (to be designated as Specification S-49), are met;

(*2*) Test requirements and other applicable parts of Specification S-34 are complied with;

(*3*) Where tubes are to be expanded in drums or headers, the hardness is limited so that properly rolled joints can be obtained;

(*4*) Where tubes are to be welded within the Code requirements, the material shall be of weldable quality.

CASE No. 868

(*Interpretation of Tables P-9 and U-3*)

Inquiry: Tables P-9 and U-3 give allowable stresses for non-killed steel and silicon-killed steel in which the silicon content is greater than 0.10 per cent. Commercially available seamless steel pipe covered by Specification S-18 may be a killed steel in which silicon is not the predominant deoxidizing element. An opinion is requested on the proper allowable stresses to apply to this grade of killed steel pipe.

Reply: It is the opinion of the Committee that for killed steel made to Specification S-18, in which the silicon content is less than 0.10 per cent, the allowable working stresses from Tables P-9 and U-3 shall be applied as follows:

Up to and including 750 F—the allowable working stresses listed for Specification S-18, seamless-killed steel pipe with a minimum silicon content of 0.10 per cent, shall be used.[1,3]

Above 750 F to 950 F—the allowable working stresses for Specification S-18, seamless non-killed steel pipe, shall be used.[2,3]

[1] The stresses for these temperatures range from 9400 to 8600 lb per sq in. with a minimum tensile strength of 47,000 lb per sq in., and from 12,000 to 10,400 lb per sq in. with a minimum tensile strength of 60,000 lb per sq in.

[2] The stresses for these temperatures range from 7650 to 2600 lb per sq in. with a minimum tensile strength of 47,000 lb per sq in., and from 9150 to 2600 lb per sq in. with a minimum tensile strength of 60,000 lb per sq in.

[3] For the complete range of stresses which constitute a revision of Tables P-9 and U-3, see February, 1939 MECHANICAL ENGINEERING, p. 171.

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the rules and its codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the code, to be included later in the proper place in the code.

The following proposed revisions have been approved for publication as proposed addenda to the code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-2*b*. Revise to read:

b Steel plates for any part of the boiler subject to pressure and not exposed to the fire or products of combustion shall be of firebox or flange quality [in accordance with Specifications S-1, S-2, S-26, or S-27].

PAR. P-21. Add the following:

c A tube in which a fusible plug is to be installed shall be not less than 0.22 in. in thickness in order to secure four full threads for the plug (see also Par. A-20).

SPECIFICATIONS S-48 AND S-49 (tentative numbers for A.S.T.M. Specifications A 209-38T and A 210-38T). Reference to these specifications to be included in Pars. P-3, P-11, P-21*a*, P-103*a*, Table P-2.

PAR. U-13*a*. Reference to Specification S-28 to be included in this paragraph.

PAR. U-13*e*. Reference to Specifications S-40, S-48, and S-49 to be included in this paragraph.

PAR. U-71*a*. Reference to Specifications S-40, S-48, and S-49 to be included in the second sentence of this paragraph.

PAR. U-120. Reference to Specifications S-28, S-32, S-48, and S-49 to be included in this paragraph.

TABLES P-9 AND U-3. The stresses for Specifications S-18, lapwelded pipe, S-32, grade A, resistance-welded boiler tubes not silicon-killed, and S-17, grade A, seamless boiler tubes not silicon-killed, are to be relocated from "Pipe Steels" heading to "Pipe and Tube Steels" heading. The following table includes the relocation of these stresses and stresses for materials not previously covered and represents a revision of only the headings listed:

Type of material	Spec. number	Grade or analysis	Minimum tensile strength	For metal temperatures not exceeding deg F: −10 to 650	675	700	725	750	775	800	825	850	875	900	925	950	975	1000
PIPE AND TUBE STEELS																		
(*a*) Non-killed* carbon steel																		
Carbon	S-18	Lap-welded open-hearth or electric	45,000	9,000	8,800	8,500	8,200	7,800	Note 2	...	...	...	...	...	...	...	...	...
Low carbon	S-32	Grade A	45,000[a]	9,000	8,800	8,500	8,200	7,800	7,400	6,900	6,300	5,700	5,100	4,400	3,500	2,600	Note 3	...
Low carbon	S-17	Grade A	45,000[a]	9,000	8,800	8,500	8,200	7,800	7,400	6,900	6,300	5,700	5,100	4,400	3,500	2,600	Note 3	...
Low carbon	S-18	Seamless open-hearth or electric	47,000[b]	9,400	9,200	8,900	8,550	8,100	7,650	7,150	6,500	5,850	5,200	4,400	3,500	2,600	Note 3	...
Medium carbon	S-18	Seamless open-hearth or electric	60,000[b]	12,000	11,800	11,400	10,700	9,950	9,150	8,300	7,350	6,350	5,400	4,400	3,500	2,600	Note 3	...
Medium carbon	S-32	Grade C	60,000	12,000	11,800	11,400	10,700	9,950	9,150	8,300	7,350	6,350	5,400	4,400	3,500	2,600	Note 3	...
(*b*) Silicon-killed* carbon steel																		
Low carbon	S-32[c]	Grade A Silicon, 0.10 per cent, min	45,000[a]	9,000	8,900	8,750	8,550	8,350	8,100	7,750	7,300	6,750	6,150	5,600	4,700	3,800	2,900	2,000
Low carbon	S-18[c]	Seamless open-hearth or electric Silicon, 0.10 per cent, min	47,000[b]	9,400	9,300	9,100	8,850	8,600	8,300	7,900	7,400	6,800	6,200	5,600	4,700	3,800	2,900	2,000
Carbon	S-40[c]	Silicon, 0.10 per cent, min	47,000	9,400	9,300	9,100	8,850	8,600	8,300	7,900	7,400	6,800	6,200	5,600	4,700	3,800	2,900	2,000
Medium carbon	S-18[c]	Seamless open-hearth or electric Silicon, 0.10 per cent, min	60,000[b]	12,000	11,800	11,400	11,000	10,400	9,800	9,100	8,300	7,400	6,500	5,600	4,700	3,800	2,900	2,000
Medium carbon	S-32[c]	Grade C Silicon, 0.10 per cent, min	60,000	12,000	11,800	11,400	11,000	10,400	9,800	9,100	8,300	7,400	6,500	5,600	4,700	3,800	2,900	2,000
Carbon	S-49[c]	Silicon, 0.25 per cent, max	60,000	12,000	11,800	11,400	11,000	10,400	9,800	9,100	8,300	7,400	6,500	5,600	4,700	3,800	2,900	2,000
(*c*) Alloy steel																		
Carbon molybdenum	S-45	Grade P-1	55,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	10,750	10,500	10,250	10,000	9,000	8,000	6,500	5,000
Carbon molybdenum	S-48	Grade T-1	55,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	10,750	10,500	10,250	10,000	9,000	8,000	6,500	5,000
Carbon molybdenum	S-48	Grade T-1a	60,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	11,500	11,000	10,500	10,000	9,000	8,000	6,500	5,000
FORGED FLANGES AND FITTINGS																		
(*a*) Non-killed* carbon steel																		
Carbon	S-8	Class 1	60,000	12,000	11,800	11,400	10,700	9,950	9,150	8,300	7,350	6,350	5,400	4,400	3,500	2,600	Note 3	...
Carbon	S-8	Class 2	70,000	14,000	13,700	13,300	12,350	11,350	10,200	8,950	7,600	6,450	5,400	4,400	3,500	2,600	Note 3	...

Specifications S-48 and S-49 are temporary designations for A.S.T.M. Specifications A209-38T and A210-38T.

All of the stresses given are related to the strength of the material and do not take into consideration the efficiency of any joint.

* The 1936 American Society of Metals' Metals Handbook defines "Killed Steel" as follows: *Killed Steel (also Dead Steel)*—Molten steel which has been held in a ladle, furnace, or crucible (and usually treated with aluminum, silicon, or manganese), until no more gas is evolved and the metal is perfectly quiet.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Historical Research

AN ENGINEER'S MISCELLANY. By Greville Bathe. Privately printed at the press of Patterson & White Company, Philadelphia, Pa., 1938. Cloth $8^3/_4 \times 11$ in., 136 pp., 93 figs. and maps, $4.50.

IN A DELIGHTFUL and beautifully printed book over which, one suspects, the author spent many happy hours, Mr. Bathe shares with his fellow engineers the fruits of his researches into the history of technology. Whether it be to recapture with the author the lost pleasures of toy steam engines which were the rewards for "good boys" in a past generation, or to discover with him the debt we owe to some struggling inventor—like Fitch or Colles—who ate the bitter bread of sacrifice to machine power in the early days of the Republic, the reader dips into the Miscellany with curious delight and finds his own problems shrinking into insignificance when compared with those which faced the pioneers of more than a century ago. By contrast with our own more advanced state of technology, we find those primitive days significant and exciting, and, perhaps, experience a vague longing for similar opportunities to usher in an era of labor-saving developments for the human race, unmindful of the still greater opportunities that lie untouched, because they are unseen, close at hand. If we sense the futility of the enthusiasm for canals that died aborning because a better mode of transportation was already in the making, we have but to remind ourselves that this frightful profligacy of obsolescence in the world of invention is but the counterpart of that same ruthless spirit of evolution by which Nature herself works her marvels. There is awakening here for the unimaginative who look upon life as completed and static; there is humility for those who think they build the foundations of their own works; there is hope for the disheartened who believe the fiction that man has achieved the ultimate and opportunity for progress is dead.

The urge for combining in the one volume what constitutes the "Engineer's Miscellany," confesses Mr. Bathe in the preface, "was not for reasons of exigency, nor even vanity, but rather to correlate a mass of data, both biographical and mechanical, which has been accumulating for several years. By invoking the aid of the printing press," he continues, "these notes can be consolidated into definite form and thus clear the desk for something new." Would that more such desks might be cleared for the benefit of engineers too absorbed in other tasks to devote themselves to historical research.

A glance at the table of contents reveals the scope of the notes thus consolidated. Thus the early artisan as depicted in art gives us some excellent illustrations from old books; the commercial toy steam engine of fifty years ago recalls the joys of the author's youth in England; the decorative era in machinery design displays some excellent examples of the architectural embellishments with which engineers once sought to disguise their strictly utilitarian structures; a digest of Fitch's steamboats provides material for a chapter in this abortive attempt to develop steam navigation in America; the first high-pressure steam engine in America (reprinted from the Transactions of the Newcomen Society) describes Oliver Evans' engine, with its wooden boiler good for fifty pounds pressure; the old Cornwall furnace records the author's studies of a famous ironworks in Pennsylvania, now a public monument, first worked by Cornishmen; the antiquity of the inclined plane on canals recalls, to those who participated in it, a "pilgrimage" of the Newcomen Society to some of the relics of the now disused Morris Canal, in New Jersey; three Cornish engineers carries the reader to Cornwall, England, and revives the names of John S. Enys, Samuel Grosse, and James Sims; the lift-wheel pumping plant of the Chesapeake and Delaware Canal is another chapter in the history of water-borne transportation that preceded the railroads; and finally, Christopher Colles and the steam engine pays homage to a brilliant Irishman, engineer and lecturer, who "was the first to build an all-American steam engine," who was the first to undertake to provide New York City with a civic water supply worked by a steam engine, and who ended his days, a pathetic but undaunted figure, eking out an existence with his telescope at the Battery, "the public paying him a small sum for viewing the harbor by day and the heavens by night."

To the Philadelphian in particular Mr. Bathe's Miscellany should appeal, as most of the historical and biographical sketches have to do with events and persons in and about eastern Pennsylvania, but all engineers will enjoy the charm of the writing, the excellence of the illustrations, and the careful attention to detail that the author exercised whenever he found himself, with camera and yardstick, on the site of his story. The chapters are ably supplemented with bibliographical references.—G. A. S.

The Science of Production Organization

THE SCIENCE OF PRODUCTION ORGANIZATION. By E. H. Anderson and G. T. Schwenning. John Wiley & Sons, Inc., New York. Cloth, $5^1/_2 \times 8^1/_2$ in., 282 pages, indexed, $3.50.

REVIEWED BY L. P. ALFORD[1]

ON AN EARLY page the authors quote this statement: "The science of organization awaits another Frederick W. Taylor, a man on the inside of business who can and will spend his time in analysis and investigation and freely pass his information on to others." They then appear to question the present-day application of this statement, which was written in 1929, and declare the main purpose of their book to be "to enhance the further clarification of this material and to synthesize the various contributions of other students of organization in order to assist in forming a more systematized body of thought."

The treatment adopted in reaching forward to this objective, while scholarly and indicating the extent of the study given by the authors, produces a form of literature that is confusing to read. In the first chapter of some 29 pages there are 89 quotations and citations, that is, the entire text is broken up and the at-

[1] Professor of Industrial Engineering, New York University, New York. Fellow A.S.M.E.

tention of the reader diverted by what appears to be an excess of quoted matter. While this method has the advantage of placing conflicting opinions in contrast, it yields a form of presentation from which it is difficult for the reader either to form an opinion of his own, or to grasp the conclusion and findings of the authors.

In the second chapter a comment of R. F. Hoxie is quoted as giving "clearly the essence of Taylor's system." The authors have seen fit to present this statement in italics: "Time and motion study, therefore, must be regarded as the first cornerstone of scientific management, its main distinguishing feature, and the point of departure for an understanding and judgment of its claims, especially with reference to its scientific character and labor welfare." In emphasizing this statement the authors appear to take the position that scientific management, or modern industrial management, is based on a measuring device. It is doubtful if they will find much support for such a contention.

If this position is accepted by the reader, the rest of the book will have meaning; if, however, the above position is rejected, the reader will find little of value in what follows.

The chapter which immediately follows the quotation just given begins a presentation of production organization from the 17 therbligs of the Gilbreths. Then comes a discussion of functions and activities, organization charts, and types of organization. In this part of the book the comparison of organization types, chapter 6, is comprehensive and instructive.

Following chapters deal with the important matter of laws, principles, and rules and are an illustration of the difficulty into which a reader is led because of the reliance upon quotations. Beginning on page 203 and running through to page 221, 14 fundamentals are discussed.

- Division of labor
- Combination of labor
- Objective or purpose
- Delegation of authority and responsibility
- Law of permanency
- Law of cross fertilization
- Law of staff and conferences
- Law of adaptability to human material
- Law of functional grouping
- Rule of appointment
- Law of internal inspection or criticism
- Rule of decentralization
- Rule of size
- Rule of measurability

To these, within the limits of a few more pages are added the four underlying principles of management formulated by Taylor.

In spite of the seemingly critical point of view taken in preceding paragraphs, the book is commended to students of the theory of industrial or production organization, for, because of its numerous quotations, it is the most comprehensive source book on its subject.

Books Received in Library

A.S.T.M. STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS, prepared by Committee D-2 on Petroleum Products and Lubricants. American Society for Testing Materials, Philadelphia, October, 1938. Paper, 6 × 9 in., 311 pp., illus., diagrams, charts, tables, $2 ($1.50 to A.S.T.M. members). This annual report of the A.S.T.M. Committee on petroleum products and lubricants includes standard testing methods, specifications, and definitions, with charts and tables where necessary. It also gives the regulations and personnel of the Committee and its subcommittees.

A.S.T.M. STANDARDS ON TEXTILE MATERIALS, prepared by Committee D-13 on Textile Materials. American Society for Testing Materials, Philadelphia, October, 1938. Paper, 6 × 9 in., 323 pp., illus., diagrams, charts, tables, $2. This is a special annual compilation of those specifications, test methods, and definitions of the American Society for Testing Materials which relate to textile materials. In addition this issue includes a psychrometric table for relative humidity, a number of photomicrographs of common textile fibers, a yarn number-conversion table, a glossary, and abstracts of papers presented in symposiums during the year.

AIR CONDITIONING. By J. A. Moyer and R. U. Fittz. Second edition. McGraw-Hill Book Co., New York, 1938. Cloth, 6 × 9 in., 455 pp., illus., diagrams, charts, tables, $4. A full and practical treatment of air conditioning, both on its theoretical side and in the selection and operation of equipment for a wide variety of applications. This second edition contains data on sun effect and on methods for calculating and selecting unit air conditioners. Useful tables and a group of practical problems are appended.

AIR NAVIGATION. By P. V. H. Weems. Second edition. McGraw-Hill Book Co., New York and London, 1938. Leather, 6 × 9 in., 587 pp., illus., diagrams, charts, maps, tables, $5. The beginning chapters are devoted to fundamental concepts, types of maps and charts, map reading, and compasses. The later chapters take up the equipment, methods, and practice of navigation by dead reckoning, blind flying, and the various systems of celestial navigation, including both preparatory work and actual flight operations. There is considerable information on meteorology and airways.

ALLOYS OF IRON AND NICKEL. Vol. 1. Special-Purpose Alloys. (Alloys of Iron Research Monograph Series.) By J. S. Marsh; published for the Engineering Foundation by the McGraw-Hill Book Co., New York and London, 1938. Cloth, 6 × 9 in., 593 pp., diagrams, charts, tables, $6. This first volume, of two, is devoted to the constitution and properties of high-purity iron-nickel alloys and special-purpose alloys. The variations in physical, thermal, magnetic, mechanomagnetic, electric, and mechanical properties are described and examined with reference to the constitution of the alloy. There are many tables and diagrams, and a bibliography of over six hundred items is included.

ANNUAL REVIEWS OF PETROLEUM TECHNOLOGY, Vol. 3 (covering 1937), edited by F. H. Garner. Institute of Petroleum, London, 1938. Cloth, 6 × 10 in., 490 pp., illus., diagrams, charts, tables, 10s 6d. This volume provides a valuable summary of the material of interest to petroleum technologists which was published during 1937. Each topic is reviewed by an authority and is accompanied by a bibliography. This year two new topics, "production engineering" and "aero engines," have been added.

APPLIED TIME AND MOTION STUDY. By W. G. Holmes. Ronald Press, New York, 1938. Cloth, 6 × 9 in., 335 pp., illus., diagrams, charts, tables, $3.75. A very practical treatment of the subject. "Therbligs," body member movements, process and motion charts, fatigue studies, and leveling and operation analysis are given detailed consideration, including a table of exact times, to four decimal places, for performing elementary motions.

CAUSES OF ECONOMIC FLUCTUATIONS. By W. I. King. Ronald Press Co., New York, 1938. Cloth, 353 pp., charts, tables, 6 × 8 in., $3.50. Business depressions are considered from the economic viewpoint. The author, after describing the characteristics of depressions, discusses various misleading or inadequate explanations of their origin and offers a further explanation, a résumé of forces which influence depressions, and possible ways to forecast and minimize depression.

DEUTSCHE KRAFTFAHRTFORSCHUNG im Auftrag des Reichs-Verkehrsministeriums. V.D.I. Verlag, Berlin, 1938. Paper, 8 × 12 in., illus., diagrams, charts, tables. Heft 11; DAUERBRUCHGEFAHR AN HOHLKEHLEN VON WELLEN UND ACHSEN UND IHRE VERMINDERUNG, by A. Thum and E. Bruder; 10 pp., 1.20 rm. Heft 12: WALK- UND KÜHLUNGSVERSUCHE AN EINEN ÜBERDRUCKLOSEN REIFEN, by L. Huber and H. P. Zoeppritz; 6 pp., 0.75 rm. Two papers of a series on motor-vehicle research. The first considers the value of cold-forming methods and proper shaping in lessening the risk of breaking in grooves around shafts. The second discusses the equipment, procedure, and results of tests performed on a segment of cushion tire in a machine simulating road shock, to determine temperature distribution and cooling effect of a special internal construction of the tire.

Deutsches Museum, Abhandlungen und Berichte, 10 Jg., Heft 4. VOM SEGELFLUG UND SEGELFLUGZEUG. By W. Hirth. V.D.I. Verlag, Berlin, 1938. Paper, 6 × 8 in., 118 pp., illus., diagrams, 0.90 rm. This is a brief essay upon gliding and gliders.

Deutsches Museum Abhandlungen und Berichte, Jg. 10, Heft 3. WEG UND WERDEN DES PAPIERS. By A. Renker. V.D.I. Verlag, Berlin, 1938. Paper, 6 × 8 in., 90 pp., illus., diagrams, maps, 0.90 rm. A brief description of the development of paper and papermaking from the earliest times to the present, covering types of paper, raw materials, methods of hand and machine manufacture and watermarks, with mention of the more important persons and places connected with the history of paper.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

New Orleans A.S.M.E. Spring Meeting Features Papers on Southern Industrial Development

Dinner and Dance, Luncheons, Trips, and Joint Sessions With L.E.S. and S.P.E.E., Feb. 23 to 25

INDUSTRIAL development and progress in the South will be the main subject of many of the technical papers to be presented at the A.S.M.E. Spring Meeting in New Orleans, Feb. 23 to 25, inclusive. Everything points to a meeting which to most of those who attend will prove unique. The problems of the engineer in the South are peculiarly his own and not only will certain of these problems be considered at the technical sessions, but every effort is being made by the Meetings and Program Committee to give members an opportunity to visit industrial plants and to witness engineering construction work typical of the industries and undertakings of that part of the country.

Headquarters for the national meeting, the first to be held in New Orleans since 1916, will be at the St. Charles Hotel. At the same time and same place, the Louisiana Engineering Society will hold its annual convention with several joint sessions being held with the A.S.M.E. On Friday, Feb. 24, a luncheon and joint session on engineering education will be held by the A.S.M.E. with the Society for the Promotion of Engineering Education. The women's committee for the meeting has arranged various events of interest for the visiting women.

Engineering Features

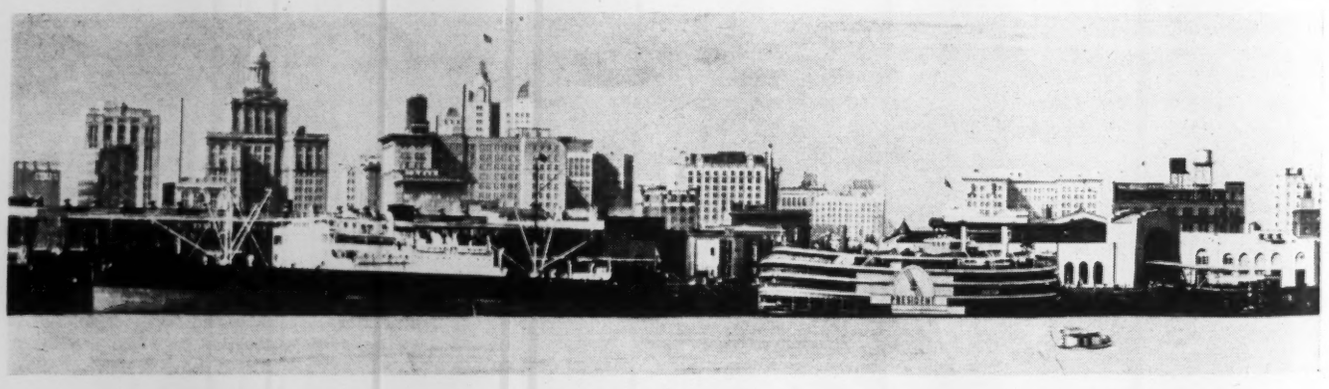
Interest in New Orleans from an engineering standpoint centers in the accomplishments of the last few years toward securing facilities adequate for handling the commerce of the Mississippi Valley with the outside world. In this respect the city and state have worked together and along with this development have come marked advances in the social and educational life of the community, through the modernization of the city government, the further development of systems of sanitation, the large-scale flood-control measures, and the growth of various educational institutions.

Points of General Interest

Besides the engineering features of New Orleans and vicinity, the visitors at the Spring Meeting will find many delightful places to visit in the city, as evidenced by the several glimpses in the illustrations appearing in this issue. The quaintness of the French quarter with its courtyards, antique stores, and famous restaurants, the tropical vegetation, the parks, and many beautiful streets, cause the city to rank high among the vacation places of the country. For those who go earlier in the week, either individually or on the A.S.M.E. tour from New York, Boston, Chicago, and other points, as described in last month's issue, there will be the gay doings of Mardi gras time in New Orleans.

High Lights

On Saturday evening a dinner and dance will be held at the St. Charles Hotel. Country-club facilities for those interested in golf and other sports will be available to all those who register. Among the trips which have been scheduled for Thursday, Friday, and Saturday afternoons, are included a visit to the Shell Petroleum Corporation refinery at Norco, a complimentary lunch, inspection of spillway, and on the way back a stop at the Godchaux Sugar Refinery at Reserve; for those interested in railroads, a special train will be furnished by the Public Belt Railroad to take visitors to the shops and then on a



THE EVER-GROWING SKY LINE OF NEW ORLEANS, THE NATION'S SECOND PORT IN VALUE OF FOREIGN COMMERCE, WITH A POPULATION OF OVER 516,000

trip over the Mississippi River Bridge and back; and for the sailors and marine engineers, a harbor tour has been arranged on a yacht furnished through the courtesy of the New Orleans Dock Board. Of timely interest to engineers and the general public will be the joint session of the A.S.M.E. and the L.E.S., on Friday evening at Dixon Hall on the campus of historic Newcomb College at which Major-General C. M. Wesson, chief of Ordnance, U. S. Army, will speak on "The Functions and Responsibility of the Ordnance Department."

Spring Meeting Committees

Handling the Spring Meeting at New Orleans is a group of active committee members, whose names follow:

General Committee
JAMES M. TODD, *chairman*
C. A. BENDER, JR.
C. C. CRAWFORD
T. R. FLOWER
F. G. FROST
G. R. HAMMETT
K. P. KAMMER
R. H. KNIPPING
B. S. NELSON
D. W. STEWART
W. E. WINSHIP
L. J. CUCULLU, *secretary*

Technical Events
B. S. NELSON, *chairman*
L. J. LASALLE, *vice-chairman*

Printing and Signs
T. R. FLOWER, *chairman*

Hotel
C. C. CRAWFORD, *chairman*
G. R. HAMMETT
J. M. TODD
CHARLES WIGGIN, JR.

Entertainment
K. P. KAMMER, *chairman*
G. R. HAMMETT
E. L. DENNIS

Plant Trips
D. W. STEWART, *chairman*
J. S. HUEY, *vice-chairman*

Information and Registration
G. R. HAMMETT, *chairman*

Publicity
C. A. BENDER, JR., *chairman*
PAUL F. HOOTS, *vice-chairman*
J. WALKER ROSS
R. H. KNIPPING

Reception
W. E. WINSHIP, *chairman*

Finance
F. G. FROST, *chairman*
C. C. CRAWFORD
A. B. PATERSON

Transportation
R. H. KNIPPING, *chairman*
R. F. MULLER
J. K. MAYER
E. A. MCLELLAN

Liaison
J. M. TODD, *chairman*

Women's Committees

Entertainment
MRS. DAVID GODAT
MRS. FREDERICK FOX
MRS. H. F. REYNICK
MRS. J. M. ROBERT
MRS. W. H. SCALES
MRS. A. FROMHERZ
MRS. WADE BARNETT

Reception
MRS. D. S. ELLIOT
MRS. W. B. GREGORY
MRS. J. M. ROBERT
MRS. KARL KAMMER
MRS. DAVID GODAT
MRS. D. ANDERSON
MRS. J. M. TODD
MRS. B. GREHAN

Registration
MRS. G. HAMMETT
MRS. F. BILLINGSLEY
MISS A. GREGORY
MRS. B. S. NELSON
MRS. C. S. WILLIAMSON

NEW ORLEANS FROM A NEAR-BY PARK

Tentative Program for A.S.M.E. Spring Meeting at New Orleans, La., Feb. 23–25, 1939

THURSDAY, FEBRUARY 23

9:30 a.m. Boiler Feedwater Studies

Grooving of Tubes in High-Pressure Boilers, by R. E. Hall and E. P. Partridge
Mechanical Purification of Steam Within the Boiler Drum, by M. D. Baker
Corrosion in Partially Dry Steam Generating Tubes, by F. G. Straub and E. E. Nelson

Management

The Industrial Renaissance of the South, by Eugene O'Brien

12:30 p.m.

Luncheon, jointly with S.P.E.E.
Address on Engineering Education

2:00 p.m. Symposium on Waste Fuel

Burning Oat Hulls, by C. J. Herbeck
Burning of Pulp-Mill Waste From a Sulphite Mill, by Grover Keeth
Burning Various Types of Oil-Refinery Fuels, by A. L. Wilson
Combustion of Wood-Waste Fuels, by Henry Kreisinger
Burning Bagasse, by E. W. Kerr
By-Product Fuels in the Steel Industry, by Gordon Fox and W. B. Clemmitt

4:00 p.m.

Council Meeting

10:00 p.m.

General Get-Together and Dance

FRIDAY, FEBRUARY 24

9:30 a.m. Power

Economics of Power Plants for Joint Utility and Industrial Service, by A. C. Klein and Thomas E. Crossan
Development of Power and Steam for Oil-Refinery Service, by C. E. Steinbeck
Mountain Creek Steam-Electric Station—An Example of Semioutdoor Construction, by Harry R. Pearson.

Safety

Fire Protection for Water Terminal Wharves and Piers, by John McKay

12:00 noon

Plant trip with luncheon at Norco, La.

Evening Ordnance

(Jointly With Louisiana Engineering Society)

Major-General C. M. Wesson, Chief of Ordnance, will deliver an address on the Functions and Responsibilities of the Ordnance Department, U. S. Army

SATURDAY, FEBRUARY 25

9:30 a.m. Petroleum

A Study of Surface Dynamometer Cards of Pumping Oil Wells, by S. B. Sargent
Design and Construction of High-Pressure Equipment Used for the Completion of Deep Wells, by Herbert Allen

Process

Cottonseed Processing Research, by W. R. Woolrich
Manufacture of Pulp and Paper, by A. W. Allison, Jr.
Sugar-Cane Milling, by Arthur G. Keller

Fuels

Lignite—A Grate-Fired Fuel of the Future in the Southwest, by C. J. Eckhardt, Jr.
Burning Modern Bunker Fuel Oils, by J. A. Hayes
Pulverized-Coal-Tar Pitch as a Fuel, by E. W. Clarke

2:00 p.m. Evening

Plant trips Dinner Dance

American Engineering Council Annual Meeting Has Fourfold Program

Assembly at Washington Coincident With Four Forums, Secretaries' Conference, and All-Engineers' Dinner

THE FOURFOLD program of the three-day nineteenth annual meeting of American Engineering Council, held at the Mayflower Hotel, Washington, D. C., Jan. 12–14, 1939, developed more in the way of variety and breadth of interest than can be adequately summarized in a report prepared from fragmentary notes and poorly integrated impressions under the pressure of the events themselves and an overdue closing date for the February issue. Comprising the four closely associated portions of the program were: the series of interprofessional forums sponsored by the Public Affairs Committee of the A.E.C., each of the four subjects discussed being under the direction of one of the several committees of the Council; the All-Engineers' Dinner, presided over by William McClellan, president, A.E.C., and addressed by the guest of honor, Vannevar Bush, president, Carnegie Institution of Washington; the business session; and the ninth Conference of Engineering Society Secretaries.

Forums a Feature of 1938 Program

Comment on two previous American Engineering Council forums, one held in Philadelphia in May and the other in Detroit in November, 1938, has appeared in previous issues. (See MECHANICAL ENGINEERING, June, 1938, issue, page 462, and December, 1938, issue, pages 899–900.) These forums, which were held for the first time in the last year, constitute a new method by which the Council is making its contributions to the public welfare through discussions of important subjects by engineers and is bringing its activities to the personal attention of a large number of engineers in widely separated sections of the country. The addresses and discussions of the first two forums have been published by the Council in pamphlet form, and the proceedings of the series of forums conducted at Washington will be similarly published.

The opening session of the Washington forums was called to order on Thursday morning by President William McClellan who emphasized the fact that the American Engineering Council wants the public to think of engineers as professional men. He introduced Frederick A. Allner, chairman, A.E.C. Public Affairs Committee, who explained the plan and purpose of the forums.

National Planning Discussed

National planning and the engineer's relation to it was the subject of the first forum. The subject was broadly treated by Harold G. Moulton, president, The Brookings Institution, Washington. He pointed out that national planning means a variety of things to many persons, and showed how planning, in one of its many phases, is very old indeed; how, in any of its forms, central national planning generally means an alternative to private enterprise that has for its function the increased production of the most needed goods and services; and how private enterprise itself is a form of national planning with a goal that is the same as that of other forms.

Charles W. Eliot, 2d, executive officer of the National Resources Committee, who was the second speaker, made it clear that under his conception planning was a function within the Constitution and consistent with free enterprise, and based on three principles: It must come from the bottom up; it must effect a correlation, coordination, and understanding among many agencies of planning; and it must be a continuing advisory process.

During the discussion which followed, in which many took part, Roy V. Wright, past-president A.S.M.E., deplored the fact that engineers were not generally consulted in local planning projects when their advice would be most valuable; and in summarizing the discussion, Dr. McClellan emphasized the fact that just as long as the engineer thought of himself as someone to be called upon by someone else, he would not be able to assist effectively in planning. He must, said the chairman, put himself in the public eye so that he will be called on to aid in the solution of public problems.

Economic Status of Professions

At the Thursday afternoon forum, presided over by John S. Dodds, chairman, A.E.C. Engineering and Allied Technical Societies Committee on Engineers' Economic Status, vice-president A.E.C., the subject was the economic status of engineering and kindred professions. The speakers were George F. Zook, president, American Council on Education, William C. Van Vleck, dean of the Law School, George Washington University, and Francis P. Sullivan, chairman of the Committee on Interprofessional Relations of the American Institute of Architects. Dr. Zook defined what he meant by a profession and said that it was characteristic of the professional ideal to place public interest above private gain. He discussed the growing demand for socialization of the professions which he considered a part of the general development toward democratic government evident on every hand.

Dean Van Vleck spoke about the legal profession and what it had done and was doing in maintaining professional standards. Mr. Sullivan opened his remarks by saying that the services of technical men depend on the confidence of the public in their profession. He reviewed the distressing plight of architects during the depression, the manner in which governmental assistance had been given to architects during this period, and made suggestions as to how a better job might have been done had advance planning been undertaken by the government for such an emergency. He said that the American Institute of Architects had voted to invite other professional societies to discuss the relations of professional men to society.

Government Reorganization

Alonzo J. Hammond, chairman of the Public Works Committee and vice-president A.E.C., presided at the third forum, held Friday morning, at which the subject, engineering aspects of government reorganization, was discussed. Joseph Pratt Harris, director of research of The Presidents' Committee on Administrative Management, and of the Committee on Public Administration, Social Science Research Council, was the first speaker. He reviewed the long history of attempted reorganization and particularly of the Reorganization bill narrowly defeated in the last Congress. He attempted to clear up many popular misbeliefs concerning the bill and its purpose, outlined its principal provisions, and dwelt somewhat on the recommendation in the bill for the establishment of a federal department of public works, which not a single Congressman on the committee favored, although the recommendation for the setting up of a department of public welfare actually got to the Congress.

E. J. Stocking, technical examiner, Civil Service Commission, described in considerable detail the method by which the Commission recruits engineers for government service. In the discussion which followed, criticism of the Commissions' methods was expressed, in reply to which Mr. Stocking made a spirited defense. Roy V. Wright expressed the opinion that the present civil-service "measuring stick" was inefficient and ineffective for professional men and asked what engineers could do about it. Votes and influence were needed, he said, and perhaps leadership could be exerted through A.E.C. Mr. McClellan pointed out that rigidities imposed by law and the Congress restricted the Commission, and said that the "politics" which made these rigidities necessary could be influenced by votes and public opinion. It was the engineer's duty to make himself effective in the molding of that public opinion, he said.

Size of Business

Engineering and economic factors in the size of business was the subject of the fourth forum which constituted the Friday afternoon session, at which Ralph E. Flanders, chairman, Engineering-Economics Committee and vice-president A.E.C., and past-president A.S.M.E., presided. The subject was presented by Willard Thorp, director of economic research, Dun and Bradstreet, Inc., N. Y., and adviser on economic studies of the Department of Commerce.

Dr. Thorp was at pains to distinguish between size of business and monopoly. He raised the question of how to measure size, and showed that different conclusions would be reached if such bases as assets and numbers of wage earners were used. Much of his discussion was based on charts used by him in testifying before the so-called antimonopoly committee of the Congress. Fortunately, a summary of this testimony appears elsewhere in this issue (see pages 159 to 163) and is along the lines of Dr. Thorp's A.E.C. discussion.

Secretaries' Conference

Twenty-one secretaries of national, state, and local engineering societies and clubs assembled on Thursday morning for the Ninth Conference of Engineering Society Secretaries. William H. Sanford, secretary Engineers Club of Philadelphia, was chairman of the conference. The principal address, on which much discussion developed, was delivered by Philip H. Gott, director, Trade Association Division, Chamber of Commerce of the United States, on the subject "The Organization Secretary and His Present-Day Responsibilities."

Ernest Hartford, assistant secretary, A.S.M.E., was chosen to serve as the chairman of next year's conference, which will be held in connection with the 1940 Assembly of the American Engineering Council. At the meeting held on Friday at the Cosmos Club plans for continuing activities throughout the coming year looking toward the program for next year's conference were discussed, and a campaign to secure the cooperation of many more engineering societies was laid.

On Thursday noon the conference sponsored a luncheon at which Brigadier-General Earl McFarland, assistant to the Chief of Ordnance, War Department, spoke on the engineer's relation to national defense. He said that there exists a unanimity of opinion that our national defense is inadequate, and that although the United States possesses the greatest potential military strength, it is unprepared for war. With the timely and effective use of our natural resources, however, he added, we may never need another war. He closed by paying tribute to engineering societies, and said that success in war depends on cooperation of engineers, industry, and labor.

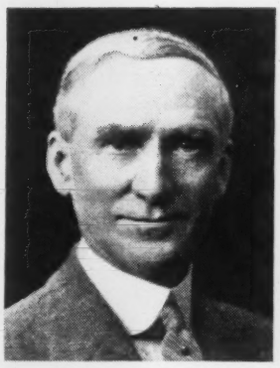
At a dinner of the secretaries on Thursday evening Dexter S. Kimball, past-president A.S.M.E., spoke delightfully and informally on the engineer as an economist.

Bush Speaks at All-Engineers' Dinner

As usual the All-Engineers' Dinner practically filled the ballroom of the Mayflower Hotel. It was held on Friday evening and was preceded by an hour of convivial assembly. President McClellan acted as toastmaster and introduced the celebrities seated with him at the head table, among whom were A.S.M.E. past-presidents W. L. Batt, A. A. Potter, and Harvey N. Davis. F. M. Feiker, executive secretary, A.E.C., read telegrams of greeting from Karl T. Compton, president, Massachusetts Institute of Technology, Mortimer E. Cooley, past-president A.S.M.E., A. W. Berresford, past-president A.I.E.E., and Herbert Hoover, honorary member A.S.M.E. and first president of American Engineering Council.

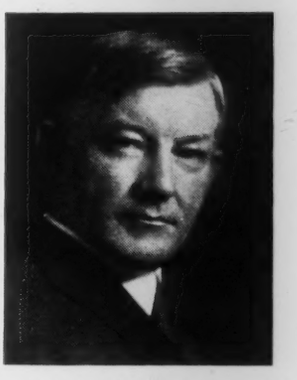
The guest of honor and speaker at the dinner was Vannevar Bush, president, Carnegie Institution of Washington, member A.S.M.E., who was introduced by Frederick Delano, a trustee of the Carnegie Institution and chairman of the National Resources Committee.

Dr. Bush delivered a brilliant address on the organization and history of the engineering profession, the relation of engineering to the other professions, the outlook for the future in view of the lessons of history, and the thread of the professional spirit that runs through the history of the development of the professions.



D. S. Kimball

Vannevar Bush



William McClellan

SPEAKERS AT A.E.C. ANNUAL MEETING

The stimulating and inspiring address will be published in the March issue. It closed with a vigorously expressed challenge to the engineering profession and a whole-hearted endorsement of American Engineering Council as the agency best suited to provide that central organization needed by the profession for the fullest development of service to society as a professional ideal and objective, without which the engineer is merely an employee having a special skill. The watchword of professions should be, he said, "ministration to the people."

In thanking Dr. Bush for his address, President McClellan said that every professional man starts as a mechanic, and that he rises above the mechanic just in so far as what he does is of service to the public and in so far as he concentrates on this thought. In summarizing the discussion of the forums he referred to the oft-repeated complaint that engineers were not brought into public questions as they should be. Such complaints, he said, were made by all professions and groups working for the public good. We live in a democratic country, he pointed out, in which progress depends on public opinion. The engineering profession, he said, must blame itself because it has not made the public conscious of its ability and availability for public service.

The engineering profession, he asserted in closing, must take up the task of becoming genuinely professional, and if the American Engineering Council does not do this, sooner or later it will be done by some other group.

Business Session and Elections

With President McClellan in the chair, the business session convened on Saturday morning. Following the roll call and passage of the customary resolution providing for joint action of the Council and the Assembly, Mr. Feiker summarized the secretary's report, which surveyed the year's activities. Among the items of major interest was the announcement of the grant of $22,500 from the National Industrial Conference Board for carrying on a joint study of the patent system in connection with the Board's study of the American system of enterprise.

In presenting the report of the treasurer, Mr. Fletcher showed a balance of more than $6000. Mr. Batt then presented a temporary budget for 1939 and explained that estimates of income were conditioned on action yet to be taken by the boards of two of the founder societies, and that the budgeted expenditures would reduce the balance to less than $1000. Mr. McClellan pledged that the Council would, as always, live within its budget, and the budget was adopted.

L. P. Alford, fellow A.S.M.E., reported for the Committee on Constitution and By-Laws, and, in view of the present financial situation which largely determined certain factors of organization asked and received permission to hold the revised draft in committee until next year.

A report of the Committee on Publicity, read by C. E. Davies, vice-chairman, secretary A.S.M.E., gave rise to a long and spirited discussion of the objectives and program of A.E.C., in which forums, finances, relationships with members of member bodies of the Council, reduced number of meetings of the Assembly (once four times a year and now annually) conduct of some Assembly functions by the Executive Committee, suggested new projects, unionization of engineers, and the *AEC Bulletin*, were discussed as well as publicity.

Mr. McBride reported for the Committee on Patents and Mr. Allner for the Public Affairs Committee.

President McClellan spoke forcefully and effectively on the serious handicap to the Council of reduced income, of apparent failure of the Council to represent the entire group of engineering societies of the country, of the evident essential function of the Council and the danger it faced of having its work taken over by some other group if its efforts relaxed or were not adequately supported, and of other problems before the Council. Mr. Alford raised the question of character of membership, which is now by organization rather than by individual engineer, and the change in conditions which made it wise to reassess the relative values of these types of membership.

For the Nominating Committee, Dean Potter, past-president A.S.M.E., presented the names of C. O. Bickelhaupt and John S. Dodds for vice-presidents to serve two years, and of Leonard J. Fletcher to serve for one year. These officers were elected by the Assembly and Council, which also elected the following chairmen of committees: Public Affairs, F. A. Allner; Membership and Representation, Warner Seely, member A.S.M.E.; and Finance Committee, W. L. Batt, past-president A.S.M.E. F. M. Feiker was reelected executive-secretary and Leonard J. Fletcher, treasurer.

The A.S.M.E. Nominating Committee Solicits Suggestions for Nominees for Office in 1940

Preferably Not Later Than April 1

THE 1939 Nominating Committee of The American Society of Mechanical Engineers requests the members of the Society to give serious consideration to the selection of nominees for elective offices in 1940 and to submit their suggestions promptly, preferably not later than April 1.

The offices to be filled are President; four Vice-Presidents, to serve two years; three Managers, to serve three years. The Constitution, By-Laws and Rules of the Society, Articles C7, B7, R7, govern the election of directors.

Complete Record Necessary

In order that a candidate may receive the fullest consideration, his sponsor should submit a complete biographical and professional record, and a list of the activities in which he has been engaged within the Society, as well as in other professional and nonprofessional organizations. The candidate's sponsor should also obtain assurance that he will serve if elected.

Officers should be men of prominence and leadership with time to devote to Society affairs. Previous service on committees and knowledge of Society affairs is a factor of importance. The president and vice-presidents must be of the member or fellow grade; managers may be of any grade of membership.

The 1939 Nominating Committee held its organization meeting the morning of December 8 and elected Dean W. L. Edel chairman and B. F. Rogers secretary for the Committee. The Committee decided to hold its executive session for final determination of candidates for the officers of the Society at The Pennsylvania State College, State College, Pa., Friday and Saturday, June 16 and 17, 1939. It is hoped that any member of the Society who would like to appear personally before the Committee to discuss any matters pertaining to nominations will do so between the hours of 10 and 4, June 16; and 10 and 12 on June 17.

It is the understanding of the Nominating Committee that representatives of the various regional groups will take definite action to get in touch with the membership of the Society directly and through the Local Sections to ascertain the desires of their respective groups regarding nominations.

The work of the Committee will be greatly expedited if seven copies of each proposal are submitted to any members of the Committee as listed:

Members of the Committee

GROUP I: W. L. Edel, *chairman*, representative, Connecticut State College, Storrs, Conn.; C. Harold Berry, alternate, Harvard University, Cambridge, Mass.

GROUP II: T. Baumeister, Jr., representative, Columbia University, New York, N. Y.; A. R. Mumford, alternate, New York Steam Corporation, 130 E. 15th St., New York, N. Y.

GROUP III: B. F. Rogers, *secretary*, representative, 650 Rudder Ave., Kingston, Pa.; C. F. Dietz, alternate, Lamson Co., Syracuse, N. Y.

GROUP IV: Dean Blake R. Van Leer, representative, North Carolina State College, Raleigh, N. C.; J. B. Jones, alternate, Virginia Polytechnic Institute, Blacksburg, Va.

GROUP V: F. C. Hockema, representative, Purdue University, Lafayette, Ind.; C. L. Bauer, first alternate, Bauer Bros. Co., Springfield, Ohio; S. R. Beitler, second alternate, The Ohio State University, Columbus, Ohio.

GROUP VI: Harold A. Smith, representative, Standard Oil Co. of Indiana, Sugar Creek, Mo.; Linn Helander, alternate, Kansas State College, Manhattan, Kan.

GROUP VII: C. I. Carpenter, representative, 1516 Old National Bank Building, Spokane, Wash.; D. R. Gray, alternate, Box 1483, Spokane, Wash.

A MARDI GRAS KING AT NEW ORLEANS AS SEEN FROM WROUGHT-IRON GALLERY

A.S.M.E. Calendar

of Coming Meetings

February 23–25, 1939
Spring Meeting
New Orleans, La.

June, 19–22, 1939
Oil and Gas Power Division Meeting
Ann Arbor, Mich.

July 10–14, 1939
Semi-Annual Meeting
San Francisco, Calif.

September 4–8, 1939
Fall Meeting
New York, N. Y.

October, 1939
Wood Industries Division Meeting
Boston, Mass.

Program of Louisiana Engineering Society Meeting

Feb. 24–25, New Orleans, La.

THE PRELIMINARY program of the meeting which the Louisiana Engineering Society is holding simultaneously with the Spring Meeting of the A.S.M.E. follows. All sessions, unless otherwise stated are being held at the St. Charles Hotel.

FRIDAY, FEBRUARY 24

8:30 a.m.

Registration opens

9:00 a.m.

Student Conference with papers by Louisiana State and Tulane students in the college of engineering

10:00 a.m.

General Meeting

Keynote address by E. L. Jahncke, secretary of the State Industrial Commission.

Installation of newly elected officers with brief reports from retiring officers

Afternoon

Inspection trips

8:00 p.m.

Public Meeting

(Dixon Hall, Newcomb College Campus)

The Functions and Responsibility of the Ordnance Department, U. S. Army, address by Major-General C. M. Wesson

SATURDAY, FEBRUARY 25

9:00 a.m.

Technical Session

Chemical Engineering and New Process Industries, by Russell S. McBride

Words, Waves, and Wires, by J. O. Perrine

2:00 p.m.

Relation of Civil Engineering to Slum Clearance and Low-Rent Housing, by Jacob Crane

7:00 p.m. Banquet

Committee Chairmen

Handling the details as chairmen of the various committees arranging the meeting for the Louisiana Engineering Society are C. J. Peirce, Jr., R. L. Nall, R. J. Kuhn, W. H. Rhodes, C. W. Ricker, E. S. Bres, H. W. Fletcher, A. L. Dunlap, and D. W. Godat.

President A. G. Christie Enthusiastically Received at Baltimore, Providence, and Boston Sections

Other Cities Visited in January Include Washington, Milwaukee, Beloit, Peoria, and Chicago

PROF. A. G. CHRISTIE, president of The American Society of Mechanical Engineers, is attempting to visit as many of the Local Sections and Student Branches of the A.S.M.E. as he possibly can, beside teaching in the day and evening, running the evening division of the school of engineering, Johns Hopkins University, and fulfilling the other duties of his Society position for which he receives no salary.

Baltimore

Nearly 100 members and guests gathered at the Merchants Club on Dec. 15 for a dinner which the Baltimore Section gave in honor of Professor Christie. Other guests included H. H. Snelling, vice-president of the Society, and A. T. Dupont, chairman of the Washington, D. C., Section. C. R. Chisholm, chairman of the Baltimore Section, presided. Tribute was paid to the new president by several members after which he gave a résumé of Society affairs and predicted a bright future in the field of mechanical engineering.

Providence

On Jan. 3, President Christie was welcomed at a dinner by 40 members of the Providence Section. Following the dinner, he presented an excellent paper on "Modern Steam Generators" as they are used both in this country and abroad.

Boston

With James Holt, chairman of the Section, presiding, Boston Section members and guests to the number of 250 welcomed President Christie on Jan. 5 at a dinner given at M.I.T., and heard him give his paper on "Modern Steam Generators" which was of interest not only to those working in the field of power generation but to all other mechanical engineers.

Other Cities

President Christie is scheduled, at the time of going to press, to be in Washington, D. C., on Jan. 19, Milwaukee on Jan. 24, Beloit on Jan. 25, Peoria on Jan. 26, and Chicago on Jan. 27. He will take as his subject "Modern Steam Generators" on which he will talk before the Local Sections in those cities. "Creative Engineering" will be his topic before the Student Branches.

News of Local Sections

Charlotte Told New Way to Condition Leaf Tobacco

MORE THAN 100 members and guests of the Charlotte Section were present on Nov. 11 to hear two papers on the "thermovacuum" method of conditioning leaf tobacco. Guest speakers were H. L. Smith, Jr., president of the Thermal Engineering Co., Richmond, Va., and the company's research engineer, Paul D. Zottu. Speaking first, Mr. Smith reviewed the experiments that led to the completion of the thermovacuum tobacco-conditioning machine by his company. The machine conditions tobacco for the manufacturing process while it is still in the hogshead. In this way, it was pointed out, there is no danger of wasting part of the tobacco as has been the case when brittle leaves were taken from the hogsheads and run through the "sweat" process. In the new machine, the hogsheads are rolled into a huge container, the doors closed, and the moisture drawn out when a vacuum is set up.

THE NEW ORLEANS WATER PURIFICATION PLANT

(The Mississippi River, less than half a mile from the plant, affords a limitless quantity of water which is steam-pumped through three large intake pipes to this plant which occupies a 74-acre plot and has a daily capacity of 160,000,000 gallons.)

Power and Management Sessions Draw Chicago Engineers

At the power and fuels session on Jan. 10, members of Chicago Section heard Lyman T. Flook, University of Chicago, describe the heating system of the school. One of the interesting parts of his talk was the description of the methods adopted in tracing and controlling the inevitable heat losses in large groups of buildings. In addition, a method of accounting has been developed whereby each building is charged with its cost of heating based on the degree-day method. With Frank C. Everitt presiding, the management session on Jan. 17 had Martin Durkin, commissioner of labor for the State of Illinois, as the guest speaker. His paper was on "Labor's Relation to Management in Industry."

475 Cleveland Engineers Hear Paper by E. G. Bailey

Preceded by a dinner, the Dec. 12 meeting of the Cleveland Section attracted 475 members and guests. The feature attraction was a talk, "Burning Coal in Modern Furnaces," presented by E. G. Bailey, member A.S.M.E., and vice-president of Babcock & Wilcox. After outlining briefly the mechanism of combustion in modern furnaces and the difficulties which are often encountered as a result of the tremendous increases in the load on steam-generating equipment, Mr. Bailey illustrated his further remarks with a series of remarkable colored motion pictures. These showed how furnaces may be cooled by a jet of steam.

James D. Mooney Talks Before Detroit Section

On Jan. 18, at a joint meeting of the Detroit Section and the Engineering Society of Detroit at the Scottish Rite Cathedral, James D. Mooney, member A.S.M.E., and vice-president General Motors Corporation, presented an illustrated talk on "Paper Money: A National and Industrial Hazard," in which he brought out the parallelism between our domestic developments and the monetary crises experienced by European nations. Mr. Mooney stressed the thorough understanding and careful treatment of this subject which will be required if we are to avoid some of the troubles which have occurred abroad. A description of the apparatus used by him to illustrate his talk appears on page 633 of the August, 1938, issue of MECHANICAL ENGINEERING.

Photoelasticity at Kansas City

Following dinner at the University Club on Dec. 9, Prof. Gerald Pickett, department of applied mechanics, Kansas State College, de-

livered a lecture on the "Photoelastic Determination of Stresses," demonstrating with polarized light and Bakelite models the nature and magnitude of these stresses in various materials.

King Cotton's Children Paper at Memphis

In a paper entitled, "King Cotton's Children," Dr. Clarence B. Weiss, experimental engineer, Buckeye Cotton Oil Co., discussed before members of Memphis Section on Dec. 20 methods of processing cotton linters, described a device for measuring the cellulose value of cotton linters, and reviewed uses of linter cellulose, including the manufacture of rayon for tires, gun cotton, celluloid, and various plastics.

North Texas Holds First A.S.M.E. Meeting in Ft. Worth

The first A.S.M.E. meeting ever held in Ft. Worth took place on Dec. 12 under the sponsorship of the North Texas Section. Speakers and their subjects were Major J. B. Hawley, "Microscopic Life in Texas Waters," and Dr. J. K. G. Silvey, "Organisms in Texas Lakes." Major Hawley's lecture centered around a motion picture of water life seen through a microscope. Dr. Silvey's talk was illustrated by a series of natural color slides showing lake sampling and treating methods.

Ontario Aeronautical Meeting

On Jan. 12, the Ontario Section presented J. H. Parkin of the National Research Council, who talked on "The Work and Equipment of the Aeronautical Laboratories."

Oregon Forestry Session

The joint meeting of the Oregon Section, A.S.M.E., and the local chapter of the S.A.E. on Dec. 9 at the Congress Hotel in Portland, consisted of a dinner, a short business session, and two papers by members of the Portland Forestry Equipment Laboratory of the U. S. Department of Agriculture. Ted P. Flynn talked on the organization of the laboratory and its part in the design of equipment for all branches of the service, including tractors and trucks. George B. Hall described the methods he used in testing filters over a four-year period which eventually resulted in extending the average life of an internal-combustion engine used in forestry work from 12,000 miles to 75,000 miles between rebores. Oil changes are only necessary at 1500 miles now as compared to 250 miles before the experiments.

Good Time Had by 120 at Philadelphia Stag Dinner

The annual frolic and smoker of the Philadelphia Section took place on Dec. 15 at the Engineers Club. D. S. Walker, secretary, reports that a good time was had by all.

Pittsburgh Has 156 at Meeting

Meeting at the Wm. Penn Hotel on Dec. 13, 156 members and guests of the Pittsburgh Section listened to a talk on "fiberglas," by L. R. Yeager, who reviewed the history of glass making and the early attempts to manufacture fiber glass, closing with a description of the present methods of manufacturing and fabricating the present-day fiberglas and the numerous uses for this product.

Air-Conditioning Paper Before Members of Schenectady Section

Recent developments and problems of the future in air conditioning, were described by H. D. Kelsey, member A.S.M.E., and air-conditioning engineer, General Electric Co. His talk was illustrated with slides, and was followed by a lively discussion.

ROYAL STREET IN NEW ORLEANS' FRENCH QUARTER
(This street is known throughout the world for its curio dealers, perfume, and antique shops.)

and described the various types of engines and fuels in use today.

Hydraulic Power Plants Paper Before South Texas Section

C. S. Adams, member A.S.M.E., and mechanical engineer in charge of design, installation, and testing of hydraulic power equipment for the Lower Colorado River Authority, spoke on "Hydraulic Power Plants" at a meeting of the South Texas Section on Dec. 30. He discussed the general layout of the hydraulic power development in progress on the Colorado River above Austin, Texas.

ONE WAY OF GETTING JUNIOR MEMBERS TO ATTEND SECTION MEETINGS
("Honor them with free cigars and sandwiches," says North Texas Section!)

110 at Worcester Meeting

At the Dec. 13 meeting of the Worcester Section, there were present 110 members and guests. The guest speaker, D. A. Munns, Bakelite Co., talked on "Industrial and Mechanical Applications of Plastics."

215 Turn Out at Syracuse to Hear Harte Cooke

Harte Cooke, vice-president of the Society, and consulting engineer with the American Locomotive Company, was welcomed to Syracuse on Dec. 12 by 215 members and guests of the Syracuse Section. In his talk on Diesel engines, he reviewed the history of the engine

Annual Meeting Movies Available to Sections

THE 1938 A.S.M.E. ANNUAL MEETING starring Dr. Harvey N. Davis, Prof. A. G. Christie, and a distinguished cast of 2500 mechanical engineers and their wives, is now available for showing at Local Section and Student Branch meetings. The 200 ft of 16-mm film takes about 10–15 minutes to show. Requests for the loan of the film should be addressed to Ernest Hartford, assistant secretary.

Fuels Division Will Supply Speakers for Sections

THE FUELS DIVISION of the Society will be happy to cooperate with Local Sections in obtaining speakers in the field of fuels and combustion. Suggestions for speakers may be obtained from Huber O. Croft, chairman of program committee, Fuels Division, University of Iowa, Iowa City, Iowa.

Judgment in Parker Case Reversed

FROM TIME to time mention of the so-called Parker Case has appeared in the A.S.M.E. News section of MECHANICAL ENGINEERING, in reports of Council and Executive Committee actions, and in Annual Reports of the Council.

The latest development in the case has been the reversal on December 23, 1938, by the Appellate Division of the Supreme Court of New York in the Appeal of the Parker Case. The Appellate Division, with five judges sitting, rendered a unanimous opinion in favor of the Society, certain of its present and former officers and members of Council, and Engineering Index, Inc., against whom John C. Parker and associates had made charges, and dismissed all of these charges. This decision completely reverses the judgment of the lower Court (by Mr. Justice Black), about which Harvey N. Davis prepared a statement for the information of members that was published on page 647 of the August issue of MECHANICAL ENGINEERING.

President A. G. Christie has sent to all members of the A.S.M.E. in the United States a statement announcing this reversal of judgment.

Actions of A.S.M.E. Executive Committee

UPON THE recommendation of the Management Division of the A.S.M.E., the Executive Committee of Council at its meeting of Dec. 30, 1938, authorized the appointment of a Committee on Depreciation to consult with representatives of other engineering societies concerned with similar problems and to develop any means or procedures which would be helpful in establishing depreciation rates. H. V. Coes and P. T. Norton, Jr., were designated as the appointees on this committee. On a recommendation of the Board of Honors and Awards, the Executive Committee of Council accepted the invitation from Iowa State College, Ames, Ia., to cooperate in the administration of the Marston Medal, and appointed Geo. A. Orrok as the representative of the Society on the Board of Award for a three-year term. The story of the establishment of the Medal is contained in the October, 1938, issue of MECHANICAL ENGINEERING on page 759.

EXCURSION TO PLANT OF SOUTHERN COTTON OIL CO. DURING SPRING MEETING

(The plant covers about thirty acres. Several thousand cars of cottonseed and tank cars of oil are processed in this plant each year.)

Junior Group Activities

Detroit Junior Group Holds Meeting in Member's Home

ON DEC. 2, the Detroit Junior Group held its third meeting of the current season, following dinner downtown, at the home of W. W. Nichols in Windsor. Here they were given a talk by William Kales, vice-president of Whitehead & Kales, who is one of the pioneers of the automotive industry. In his talk, Mr. Kales traced the steps which led to the founding of the automotive industry, especially the Ford Motor Company. He described Henry Ford, member A.S.M.E., as a man who besides doing a full day's work as chief engineer of The Detroit Edison Co., also did another full day's job as an inventor. Mr. Kales then told of his own personal experiences with the early cars and of the struggle of the companies in getting started. Almost before he had finished, the Juniors had started the discussion which continued until the lateness of the hour made it necessary to adjourn. Besides the eleven Juniors, there was present M. W. Benjamin, chairman of the Detroit Section.

Cleveland Juniors Hear About Built-Up Edge

THE JUNIOR GROUP of the Cleveland Section at its monthly meeting on Dec. 19, listened to a paper by Dr. V. D. Prian on "A Discussion of the Built-Up Edge." In it he told how the occurrence of the built-up edge in the art of cutting metal, as in turning a steel shaft, was not recognized in technical literature until 1899. Even after that, its importance was not recognized until 1934 when extensive research on the problem was undertaken. The presentation was augmented by slides of photographs taken by Dr. Prian in the course of his research and by motion pictures.

San Francisco Juniors Hold Seminar on Process Industries

ON DEC. 15, the San Francisco Junior Group assembled, under the chairmanship of Marion B. Hughes, for another lively seminar. Process industries was the theme of the session. The discussion was started by Edward E. Polomik, chemist for Libbey, McNeil & Libbey, who described the process used in canning pears, covering the canning, syruping, and the method of exhausting, sealing, and cooking the canned pears.

W. M. Brashear, assistant plant engineer for Colgate-Palmolive Peet Co., followed with a very enlightening description of the manufacture of soap in which he traced the various steps from the raw materials to the finished products. Two odd facts were brought out — the demand for soap falls off in winter months, and second, soapmaking is an art and not a science, the chief soapmaker has to taste the soap to determine if it is finished.

A. T. Cox Addresses Tri-Cities Juniors

THE NOV. 29 meeting of the Junior Group of the Tri-Cities Section was held in the Rock Island Arsenal Auditorium and was attended by approximately 75 members and guests. Chairman Carl Hand introduced the speaker for the evening, A. T. Cox, Lincoln Electric Co., who spoke on "The Fundamentals of Arc-Welding Practice and the Redesign for Welded Construction." Both slides and motion pictures were used to illustrate the advantages of welded-steel construction overcast-iron construction.

An inspection trip was made on Dec. 7 by members of the Junior Group to the Dewey Portland Cement Plant at Linwood, Iowa. The various steps in the manufacture of cement were followed through from the grinding of the limestone and the clay from which the cement is made to the sacking of the finished cement.

With the Student Branches

Central Illinois Section Offers $25 in Prizes to Illinois Branch Members

All A.S.M.E. Student Members May Compete in Local Sections, Charles T. Main, and Student Award Contests and for Group Meeting Prizes

CENTRAL ILLINOIS SECTION of the A.S.M.E. has offered $15 as first prize and $10 as second prize for the best papers presented in competition by undergraduate student members of the UNIVERSITY OF ILLINOIS BRANCH. The awards will be presented to the two student members who, in the opinion of the judges, have presented the best papers, both written and oral, based on the organization of the material, development of the paper in accordance with the subject as stated, and the correct use of English, both written and oral.

The purpose of the Section in establishing these awards is to encourage students in broadening their experience, both in writing on technical subjects and in presenting technical papers before groups of engineers. Rules for the competition state that a minimum of five papers must be entered in the competition by the Branch on subjects applicable in the field of mechanical engineering. Each paper must be an original presentation and contain a concise bibliography and not less than 2000 words; however, the oral presentation for which there is no time limit must be made from not more than an outline. Subjects must be presented on, or before, Jan. 9, written papers must be in on, or before, April 15, and oral presentations will be made some time during the week of May 1 at a meeting of the Branch.

Old Guard Prizes

Those members of the Society who have been members 35 years or more have voluntarily contributed a sum of money which is administered in behalf of student members by a committee of the Old Guard. Each year this committee places in the hands of the Committee on Relations With Colleges $100 to provide ten special Old Guard Prizes of $10 each, to be administered with the other prize money set aside by the Society for each of the Ten Student Group Meetings held each spring throughout the country.

Charles T. Main Award

Charles T. Main, past-president of the Society, established a fund in 1919 to provide a cash award of $150 to be given annually for the best paper submitted by a student member in a competition. The subject for 1939 is "The Economics of Investment in New Manufacturing Equipment—With Concrete Cases," and the paper, containing not less than 2000 words, must be submitted to the Society on, or before, June 30, 1939. The story of the award appears in the November, 1938, issue of MECHANICAL ENGINEERING.

Student Awards

Two annual cash awards of $25 each, made possible by a fund created by Henry Hess, past vice-president of the Society, are given with engraved certificates, signed by the President and Secretary of the Society, for the papers on any engineering subject or investigation, prepared by student members and submitted on, or before, June 30 of each year. One award is presented to a graduate student and the other to an undergraduate student. A complete history of the awards can be found in the December, 1938, issue of MECHANICAL ENGINEERING.

Student Group Meeting Prizes

At each of the ten Student Group Meetings, held each spring in various parts of the country, cash prizes amounting to $85, exclusive of the $10 given by the Old Guard Committee, are awarded to the students presenting the best papers as selected by a board of judges. In addition to the above cash prizes, SKF Industries, Inc., of which William L. Batt, past-president of the Society, is president, gives a slide rule at each of the meetings. It has been estimated that the value of all prizes given at these meetings amounts to more than $1000 every year.

Local Sections Prizes

In addition to Central Illinois Section, the following Local Sections of the A.S.M.E. also give cash prizes or junior-membership awards. It should be noted that these junior memberships, which are paid-up dues for one year, are awarded on condition that the election of the students to the next higher grade receives favorable action by the Admissions Committee.

Anthracite-Lehigh Valley Section—Student Branches: Lafayette College and Lehigh University. Prizes: To each branch a Junior membership (value $10) to be awarded to student member doing most for branch or standing highest in class.

Boston Section—Student Branch: Northeastern University. Prize: Carfare paid to group meeting.

Chicago Section—Student Branches: Armour Institute, Northwestern University, and Lewis Institute. Prizes: To each student branch a Junior membership (value $10). Basis of award not stated.

Florida Section—Student Branch: University of Florida. Prizes: $10 each semester for best papers, distribution on basis of $5, $3, and $2 each. In addition, the section gives an honorarium of $5 to each student who presents a paper at a local-section meeting.

Inland Empire Section—Student Branches: University of Idaho and Washington State College. Prizes: To each branch a Junior membership (value $10) for best paper presented during year; and a cash prize (amount not stated) for the second best paper.

Knoxville Section—Student Branch: University of Tennessee. Prize: $10 for best paper presented by student member.

Los Angeles Section—Student Branches: California Institute of Technology and University

YALE STUDENT MEMBERS MAKING TOUR OF NEW YORK HARBOR ON NOVEMBER 15, 1938, AS GUESTS OF THE PENNSYLVANIA RAILROAD

(The trip started at 5:30 a.m. and the boys look pretty wide-awake, considering the hour.)

of Southern California. Prizes: $25 in prizes for best papers presented by student members at a joint meeting.

Mid-Continent Section—Student Branches: University of Oklahoma, University of Arkansas, and Oklahoma A.&M. College. Prizes: To each a slide rule (value $5). Basis of award not stated.

Minnesota Section—Student Branch: University of Minnesota. Prizes: Three prizes, $25 and handbook (value $8); $15 and handbook (value $8); and $10 and handbook (value $8), for best student papers.

Nebraska Section—Student Branch: University of Nebraska. Prize: Junior membership (value $10) to student member based on his A.S.M.E. activity, his scholarship, and his presentation of papers at branch meetings.

New Orleans Section—Student Branches: Tulane University and Louisiana State University. Prizes: None. However, a donation is made to each branch's fund for transportation of student members to the regional Student Meeting.

Oregon Section—Student Branch: Oregon State College. Prizes: Three prizes, $15, $10, and $5, for best papers presented at joint meeting.

St. Louis Section—Student Branches: University of Missouri, Washington University, and Missouri School of Mines. Prizes: One Junior membership (value $10) to each student branch. Basis of awards not stated.

South Texas Section—Student Branches: Rice Institute, Texas A.&M. College, and University of Texas. Prizes: Two prizes, $15 and $10, for best papers presented at a joint meeting.

Tri-Cities Section—Student Branches: Iowa State College and University of Iowa. Prizes: To each branch a Junior membership (value $10) for the best paper and $5 in cash for the next best one.

Utah Section—Student Branch: University of Utah. Prize: Junior membership (value $10) for best undergraduate thesis by student member.

Virginia Section—Student Branches: University of Virginia and Virginia Polytechnic Institute. Prize: Junior membership (value $10). Basis of award not stated.

Washington, D. C., Section—Student Branches: George Washington University, University of Maryland, and Catholic University. Prize: To each branch a Junior membership (value $10). Basis of award not stated.

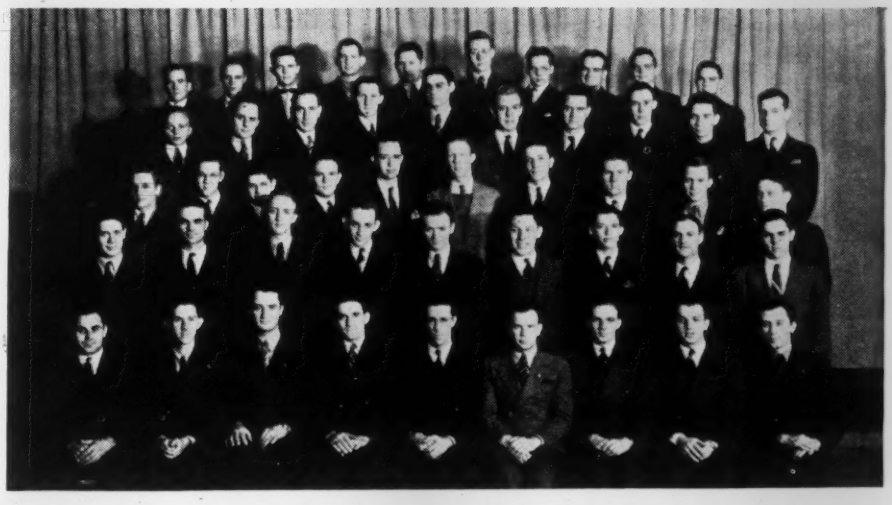
About the Branches

Prize Contest at Arizona

IN ORDER to foster interest in the A.S.M.E. national awards to student members, ARIZONA BRANCH is sponsoring a contest within the Branch itself for prizes of $5, $3, and an engineering biography for the three best papers presented by members.

AKRON BRANCH had as guest speaker on Nov. 22, M. Vance, retired chief engineer of the B. F. Goodrich Co., who reviewed developments in power and illumination in the last two-score years.

BROOKLYN POLY BRANCH members are thinking of making or buying a bulletin with a neon sign. Leave it to the mechanicals to think up new novelties.



MEMBERS OF THE A.S.M.E. STUDENT BRANCH AT PURDUE
(This Branch has so many members that the photograph was taken in batches!)

California Has Good Meeting

On Nov. 29, CALIFORNIA BRANCH presented three speakers, two students, and one guest engineer. Albert Champian, student member, talked on "The Electric Indicator for High-Speed Engines." The method consists of using a photoelectric cell for measuring volume and carbon granules for indicating pressure, the two values being shown as a pressure-volume diagram on a card or on a cathode-ray screen. The second speaker, Josh Brady, chairman of the papers committee, spoke on "Engineers Plus What?" or "How to Get Along With Life." Following these two speakers, Mr. Dittus of the Standard Oil Co. showed motion pictures and described the operations of his company abroad. This was the last meeting at which John T. Dawson presided as chairman since he was graduating in December. Richard Puck, vice-chairman, becomes the new chairman.

CATHOLIC UNIVERSITY BRANCH members met in the school's power plant for their Dec. 6 meeting. Anthony Bayer, student member, described the U. S. Army's 155-mm gun and its operation. Following him, Chairman O'Neil introduced Paul Garber, head of the bureau of aeronautics of the Smithsonian Institution, who was one of the country's first air-mail pilots. He gave an illustrated talk on the progress of the air mail from its beginning until the present day.

Two Meetings at Cornell

At the Nov. 29 meeting of the CORNELL BRANCH, Richard G. Smith, student member, presented a paper on "Testing Aircraft Engines," material for which was drawn entirely from his experiences as a junior test engineer with the Pratt & Whitney Aircraft Corp. this last summer. After an enjoyable dinner with members of the Ithaca Section on Dec. 9, student members heard Prof. G. B. Upton describe "How Mufflers Perform." After a short recess, Prof. W. N. Barnard, director of the Sibley School of Mechanical Engineering at Cornell University, gave an illustrated talk on the $6,000,000 building program of the school, which was reported in this section last month.

Delaware Father-and-Son Smoker

The Dec. 1 monthly meeting of the DELAWARE BRANCH was a father-and-son smoker. Guest speaker was Mr. Wilson of the du Pont Company, who reviewed the qualities necessary in "The Young Engineer of Today." According to him, the most important points are straight thinking, personality, and the ability to get work done. After the talk, the fathers made an inspection trip through the school's laboratories and shops.

DREXEL TECH BRANCH had a sizable delegation at the 1938 Annual Meeting of the A.S.M.E. in New York. Needless to say, they all had a good time.

FLORIDA BRANCH members saw the motion picture called "The Harvest" on Dec. 9 through the courtesy of the Ford Motor Company.

Georgia Has Nobel Prize Winner as Speaker

On Friday, Nov. 18, GEORGIA TECH BRANCH in collaboration with the Atlanta Section, A.S.M.E., staged a student meeting at the school which was attended by approximately 500 students, faculty, and section members. The speaker was Dr. Arthur H. Compton, who was awarded the Nobel Prize in Physics in 1927. His talk covered the relationship between the engineer and society.

IOWA STATE BRANCH on Dec. 7 had Prof. L. F. Hummel give a talk on how to prepare and partake in employment interviews. The Iowa boys are certainly starting early to get ready for graduation in June.

Kentucky Picture Taken

No guest speaker, no inspection trip, but an assembly on the steps of the Engineering Building on Dec. 2 of the members of KENTUCKY BRANCH for their annual group picture. Fifty years from now, grandpappy will be saying to grandson, Johnny, "That's me, there."

LOUISIANA STATE BRANCH members heard Flaherty present a paper on fatigue cracks on turbine blades and methods of determining these faults.

MEMBERS OF STUDENT BRANCH OF A.S.M.E. AT THE UNIVERSITY OF NORTH DAKOTA
(This picture was taken while the boys were taking a field trip through State Mill at Grand Forks, N. D.)

Profs Roasted at Michigan

A time-honored and traditional affair took place on Dec. 14, when MICHIGAN BRANCH held its annual "Roast." After a sumptuous feast at the Union, the 150 members and guests settled down to a night of fun and entertainment. Chairman John M. Stevens introduced Honorary Chairman E. T. Vincent, who explained the significance of the affair and how it gave students an unheard of opportunity of putting their professors on the grill and roasting them. This year, however, the winner was chosen not only on his good sportsmanship, but also on his intelligence as revealed by a set of trick questions fired at each candidate by Program Chairman Donald F. Van Loon. After a close race, Prof. Axel Marin won the "Spoo-fun-cup" and received it from last year's winner, Dean H. C. Anderson.

MICHIGAN STATE BRANCH continued its policy of having members present papers at the weekly meetings. Recent speakers were D. C. Bender, John Blunt, Albert Booth, V. C. Carlson, A. L. Johnson, H. S. Keller, A. D. Kerkau, R. G. Lloyd, J. W. Macomber, Bernard Maurer, Henry Cohn, D. H. Kelly, H. D. Chicoine, R. C. Clough, W. R. Clow, and C. A. Gladden.

Missouri Inspection Trips

Inspection trips were made on Dec. 10 by members of MISSOURI BRANCH to the plants of the Chance Manufacturing Co. and the Panhandle Pipe Line Co.

MONTANA STATE BRANCH members, following luncheon on Dec. 1, heard Thayer Landes describe "Steam-Powered Automobiles," and George Clemow discuss "Lubrication of Steam Engines."

NEVADA BRANCH had Melvin M. Tilley give a paper on "Liquid Clutches Used in Automobiles" at the Dec. 2 meeting, and a paper on "The Shell Cleaner Process" at the Dec. 9 session. However, at the latter meeting, another speaker was William Orr, who spoke on the "M.I.T. Wind Tunnel."

Newark Meeting Attracts 102

The December meeting of the NEWARK BRANCH was held on Dec. 5. The speaker of the evening was Mr. Kissam, Linde Air Products Corp., who illustrated his talk on "Arc Welding" with motion pictures and a demonstration of welding.

N.Y.U. BRANCH (aero division) inaugurated a new series of meetings on Dec. 14 by having Professor Coburn, Guggenheim School of Aeronautics, speak on the requirements of the aviation transport industry. He warned the future engineers to consider the human capacity of the pilot and not ask him to use more instruments than he can within human limitations.

PENNSYLVANIA BRANCH showed a motion picture on "Safety Glass" at the Dec. 12 meeting.

Classrooms at a Premium at Penn State

Classrooms are at such a premium that it's almost "standing room only" at the PENNSYLVANIA STATE COLLEGE this year. Athletic locker rooms, attics and basements of several buildings, clubrooms for students, storage rooms under a water tower, space in the

LOUISIANA STATE UNIVERSITY STUDENT MEMBERS VISITING THE FREEPORT SULPHUR CO. PLANT ON NOV. 12

MEMBERS OF THE A.S.M.E. BROOKLYN POLYTECHNIC INSTITUTE BRANCH

women's recreation building, even storage rooms in barns for sheep, all have been pressed into service for the 6735 students at PENN STATE during the present building program.

PRATT BRANCH has the honor and distinction of sending in the first meeting report of 1939. At the meeting of Jan. 5, plans were made for speakers and topics for the coming term.

RENSSELAER POLY BRANCH heard a talk on the "History of Locks" by Maxwell C. Maxwell, assistant to the president, Yale & Towne Manufacturing Co., at the Dec. 14 meeting.

Santa Clara Inspection Trip

Monday evening, Dec. 12, SANTA CLARA BRANCH members made an inspection trip through the Rickard Memorial Observatory on the campus of the University. It was in this observatory that Father Rickard, S.J., the "Padre of the Rains," formulated and proved by actual test his famous sun-spot theory of storm prediction, says Frank Booth in a report of the trip. The members were led through the darkroom in which day-by-day photographic records of the earth movements are developed. The group then descended into the seismograph chambers where the operation of the delicate recording machines was explained by Dr. Newlin, director of the observatory. Finally, the party saw the solar telescope in the dome of the observatory.

SYRACUSE BRANCH in conjunction with the student branches of the A.I.E.E. and the A.S.C.E. is sponsoring an all-engineers' forum which will make it possible to invite prominent outside speakers and assure them a sizable audience.

170 at Texas A.&M. Meeting

At the meeting on Nov. 29, 130 members of TEXAS A.&M. BRANCH and 40 guests heard Mr. Dobbs, Socony Vacuum Co., give a talk which was illustrated with motion pictures. Since all juniors and seniors in the M.E. department are already enrolled in the Branch, the membership committee is now going after the freshmen and sophomores to join as associate members. To make programs interesting, each bi-weekly meeting is arranged in its entirety by one of the four classes. It is reported that at the last meeting, the freshmen gave out cigars.

TEXAS BRANCH Corresponding Secretary Harold B. Crockett reports the Dec. 12 meeting as follows: Guest speaker was Robert J. Smith, vice-president of Braniff Airways. For one thing, he is the "smoothest" speaker the Branch has had the opportunity to hear. His manly build and radiant personality diminished somewhat the astonishment of the group that one of only about 35 years of age should hold such a responsible position. Mr. Smith's speech was as streamlined as the Lockheed "12" which brought him to the campus. Quite naturally, it concerned air transportation—past, present, and future.

Utah Sees "Wizardry of Wireless"

UTAH BRANCH presented a motion picture on "Wizardry of Wireless" at the Dec. 7 meeting. The rest of the meeting was devoted to two talks, based on articles in MECHANICAL ENGINEERING, presented by James Adamson and Grant Bagley.

VIRGINIA BRANCH requires all first-year men to write papers for a contest which is sponsored by the Branch.

George Washington Branch Helps Form Engineers' Council

To foster coordination of programs among the various engineering society branches on the campus, the GEORGE WASHINGTON BRANCH helped to form an engineers' council for this purpose. The plan was approved at the meeting of Dec. 14, at which Joseph Hartman also presented a paper on the electric-steam boiler.

WASHINGTON BRANCH on Dec. 1 heard Tom Gaynor describe "Interesting Construction Points at Grand Coulee," based on his personal experiences as a workman on the project last summer. William Kaye talked on "Radial Expansion in Gun Construction," and Paul Sherwood described the process of producing "Frozen Foods," illustrating it with actual samples of cherries and strawberries which were eventually eaten with much enjoyment by the audience.

West Virginia Hears Papers by Branch Members

WEST VIRGINIA BRANCH also encourages members to give papers. Recent speakers were J. L. Cestario, D. Fast, R. S. Small, R. E. Radabaugh, E. J. Amato, J. B. Anderson, C. A. Anderson, R. K. Winters, D. J. Snyder, E. R. Cokeley, W. H. McIntyre, P. A. Whalen, T. R. Wilson, E. P. Baldwin, and W. C. Reynolds.

Rutgers to Enlarge Its Engineering Building

ADDITIONS to the present facilities of the Engineering Building at Rutgers University will increase the laboratory space available for engineering students by 6242 square feet or about 57 per cent. The work will be started shortly and will be financed jointly by the university and the Works Progress Administration, which recently approved a grant of $34,576 for the project. The additions and alterations consist of two parts, one of which will provide for the construction of a new wing in the rear of the present building, and the other for reinforcing the floor over the swimming pool in the present Ballantine Building. This pool is the only unit remaining from the old Ballantine Gymnasium, which was destroyed by fire in 1930. The pool has been used by the department of engineering as a hydraulics laboratory since the present Ballantine Building was completed in 1932.

FLOAT OF A.S.M.E. STUDENT BRANCH IN NORTH DAKOTA AGRICULTURAL COLLEGE HOMECOMING PARADE, FARGO, N. D., OCTOBER 29, 1938

(Below the rotating earth is a band revolving in the opposite direction on which is inscribed "We're Helping North Dakota Keep Up With the World!")

National Patent Inquiry to Be Conducted by A.E.C. and N.I.C.B.

A COMPREHENSIVE investigation of the whole patent problem has just been started by the National Industrial Conference Board, independent fact-finding organization of management and labor. Technical phases of the investigation will be supervised by the Committee on Patents of the American Engineering Council, while the economic aspects will be analyzed by the Conference Board's economists under supervision of Dr. Robert F. Martin, director of the Economic Research Division of the Board. Much work on the patent situation has already been done by the A.E.C. Committee under the chairmanship of Dr. R. S. McBride, consulting chemical engineer. The other members of the committee are: James H. Critchett, general manager, Union Carbide & Carbon Research Laboratories, Inc.; William M. Grosvenor, consulting chemist and factory engineer; Frank B. Jewett, president, Bell Telephone Laboratories; Warner Seely, member A.S.M.E., and secretary, Warner & Swasey Co.; and Kenneth H. Condit, member of A.S.M.E. Council, and executive assistant to the president, National Industrial Conference Board. Close cooperation with other organizations concerned with this problem is assured through representation on their patent committees by members of the Board's staff.

Every phase of the patent problem will be studied by the experts of the Conference Board and Engineering Council. Five main headings are included in the outline of the inquiry. Under the general topic "Invention," there will be a study of the origin of inventions and a review of independent and organized invention. Such matters as costs, types of invention, work on inventions, use of patents, and foreign experience will also be covered.

Perhaps the most important subject of the five concerns the social and economic effects of invention. Under this heading the effects on consumers, labor, capital, and management will be studied in detail.

A third heading covers an examination of the patent system itself and the functioning of the Patent Office. Consequences of the patent system as shown by stimulation of invention and discovery are covered in another section. The final heading includes a critical review of the functioning of the patent system, and of current criticisms and proposed reforms.

Design Committee—a Correction

IN A REPORT of the 1938 Annual Meeting published in the January issue, announcement was made (page 48) of the organization of a design committee. This announcement, based on information that was considered reliable, stands in need of correction. It should have read:

In order to fill the needs of members interested in design work, it was suggested that each professional division organize a design committee within its field. After some discussion, it was thought best to abandon this idea or the one of having a separate design division within the Society. Consequently, design activities will be continued under the sponsorship of the subcommittee on Machine Design, Machine Shop Practice Division, whose chairman is Prof. E. S. Ault and new members are A. E. R. deJonge and J. Marin.

Testimonial Dinner to Crosby Field

A TESTIMONIAL DINNER to Crosby Field, retiring chairman of the Standing Committee on Professional Divisions was arranged by Chairman L. K. Sillcox at the University Club at 6:30 p.m., Tuesday, January 10, 1939. Those attending the dinner were: Crosby Field, L. K. Sillcox, W. A. Shoudy, C. B. Peck, G. B. Karelitz, Harte Cooke, G. B. Pegram, W. A. Carter, Elmo Caruthers, C. E. Davies, G. A. Stetson, and Ernest Hartford.

A framed certificate inscribed with the names of his fellow members on the Committee and taking cognizance of his excellent service during his term of 5 yrs, the last two of which he served as chairman, was presented to Mr. Field.

Conference on Instrumentation in Process Industries

PLANS have been formulated for a conference on instrumentation in the process industries, sponsored by the chemical-engineering department of the Carnegie Institute of Technology, Pittsburgh, Pennsylvania, on March 2–3, 1939. The purpose of the conference is to bring about a better knowledge of the advance made in measurement and control in the process industries. An exhibit will be held in conjunction with the conference. Dr. C. C. Monrad of the department of chemical engineering is in charge of the arrangements.

General Magnus Mowat Retires as Secretary of I.M.E.

THE COUNCIL of The Institution of Mechanical Engineers (Great Britain) announces with regret the retirement, because of ill health, of Brig.-General Magnus Mowat, C.B.E., for 18 years secretary of the Institution. In view of his services the title of honorary secretary has been conferred on him. General Mowat is a fellow of The American Society of Mechanical Engineers.

Chilled-Car-Wheel Research Started at Battelle Institute

A RESEARCH project on chilled irons for use in car wheels, was established recently at the Battelle Memorial Institute, under the sponsorship of the Association of Manufacturers of Chilled Car Wheels. The work will comprise a critical study of the material in current use and of new compositions in the iron-carbon group of metals.

Local Sections

Coming Meetings

Anthracite-Lehigh Valley: February 24. Wyomissing Club, Reading, Pa., at 8:00 p.m. Subject: "Industrial Waste Problems and Their Correction," by S. T. Powell, consulting engineer of Baltimore, Md.

Bridgeport: February 14 or 16. Stratfield Hotel, Bridgeport, Conn. Subject: "Metal Cutting," by Malcom F. Judkins of the Firth-Sterling Steel Co., McKeesport, Pa. Mr. Judkins is chairman of the A.S.M.E. Special Research Committee on Cutting of Metals.

Charlotte: February 3. Thacker's Restaurant, Charlotte, N. C., at 7:00 p.m. Subject: "Materials Handling," by Maxwell C. Maxwell, assistant to president, Yale & Towne Manufacturing Co., New York, N. Y.

Cleveland: February 6. Guild Hall, 45 West Prospect Ave., Cleveland, Ohio, at 8:00 p.m. Subject: "Our Coast Guard Goes to Work," by Capt. G. W. Cairnes, Division Engineering Officer, U.S.C.G.

Detroit: February 28. Detroit Yacht Club at 6:00 p.m. Subject: "Mechanical Engineering in the Pharmaceutical Industry," by Harvey M. Merker, manufacturing superintendent of Parke, Davis & Company.

Ontario: February 15. University of Toronto, Toronto, Ont., Can., at 8:00 p.m. Subject: "Modern Steam Generators," by Prof. A. G. Christie, president of the A.S.M.E., and professor of mechanical engineering at Johns Hopkins University, Baltimore, Md.

Philadelphia: January 24. Engineers Club of Philadelphia at 7:45 p.m. Subjects: "The Centrifugal Pump for Higher Temperature & High pressure," by W. H. Waterman, Byron-Jackson Co., New York, N. Y.; "Gas Expanders and Compressors," by Paul Clarke, president of Clark Brothers, Olean, New York.

Pittsburgh: February 7. Cardinal Room of the William Penn Hotel, Pittsburgh, Pa., at 8:15 p.m. Subject: "Improvement in Fuel-Burning Equipment," by C. A. Reed, director of engineering, National Coal Association, Washington, D. C.

Rock River Valley: February 16. Rockford, Ill., at 7:00 p.m. Subject: "Industrial Research," by L. W. Wallace, director of engineering and research, Crane Co., Chicago, Ill. This will be a joint meeting of the Rock River Valley Engineering Council.

San Francisco: February 23. Engineers Club of San Francisco. Dinner at 6:00 p.m., meeting at 7:30 p.m. Subject: "Plastics and Their Manufacture," by some speaker from Los Angeles. It is also hoped to have the moving picture "Modern Plastics Preferred."

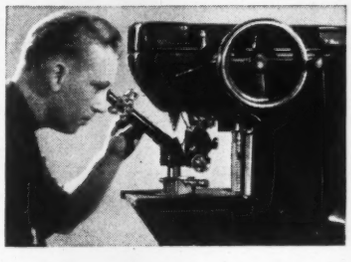
Worcester: February 16. Sanford Riley Hall, Worcester Polytechnic Institute. Dinner at 6:45 p.m. Meeting at 7:45 p.m. Subject: "Welding and Ordnance Construction," by W. L. Warner, welding engineer from Watertown Arsenal.

(*A.S.M.E. News continued on page 188*)

300,000 OPERATIONS

AND STILL IN GOOD WORKING CONDITION

This veteran served five years on a heat recovery line, being partially opened and closed every four minutes seven hours a day for five years—exceptional service even from a valve of exceptional quality. A tribute to the practical applications of Crane research.



". . to unearth new facts"

Recently, the newly completed Crane Research Laboratories, housing the largest and best equipped research facilities in the industry, were opened to public view. In the foreword of a booklet published on this occasion, President Charles B. Nolte says:

"Research is misunderstood by a great many people, but in its simplest form it may be defined as an organized and diligent application of existing knowledge to unearth new facts. . . . Crane Co., therefore, is dedicated to the philosophy that only through continuing a well-organized program of research can it best serve its employees, its stockholders, the users of its products, and society in general."

TRANSLATING RESEARCH INTO DOLLARS FOR YOU

Crane research has as its objective the saving of dollars in your plant operation—the improvement of those valves and fittings whose responsibility it is to control all phases of flow.

Research in design and in new alloys has resulted in multiplying the life of valve stems—this improvement translated into longer life means dollars for you. Valve seats have greater resistance to erosion and corrosion because of research—and again research cuts your costs—saves you money.

Alloys have been developed capable of withstanding the searing cold of 150 degrees below zero—the scorching heat of 1300 degrees above, opening up new fields for you in the handling of liquids or gases at greater ranges in temperature. And in welding new alloys, Crane research has developed new techniques that make their use practical. Again this means increased production—more dollars in profit for you.

But research does not stop with these spectacular achievements . . . it also provides an accurate control of manufacture that guarantees the uniform, high quality of the valves and fittings you buy from Crane.

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NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

Men and Positions Available

Engineering Societies Employment Service

MEN AVAILABLE[1]

GRADUATE MECHANICAL ENGINEER, 24. Broad, practical, and theoretical experience with marine, power-plant, and pumping-station equipment. Now employed. Desires active engineering work. Location immaterial. Me-220.

MECHANICAL ENGINEER, 21, M.I.T. graduate. Specialized in heating, ventilating, refrigeration, and air conditioning. Some experience in engine room of fairly large ice-cream manufacturing company. Desires position with engineering future. Me-221.

ENGINEERING EXECUTIVE, M.E. Purdue; 15 years' experience manufacturing and 15 years' selling and advertising various industrial products. Recently specializing in automatic control of industrial processes, sequence, temperature, pressure, flow. Me-222.

GRADUATE MECHANICAL ENGINEER, 22, seeks employment with progressive company manufacturing automobile or aircraft engines. Willing to start at bottom and work up. Good draftsman. Salary secondary. Location U. S. Me-223.

MECHANICAL ENGINEER, M.I.T. graduate. Available for position of assistant chief engineer. Now in process industry employing 1500. Experience in design and drafting supervision, electrical engineering, power plant, and building construction. Me-224.

INSTRUCTOR OR POWER PLANT ENGINEER, age 32, married. Twelve years' marine engineering experience as commissioned naval officer. In charge modern marine steam plant now. Electrical and Diesel experience. Mechanical engineering, M.S., California. Me-225-3812-D-2 San Francisco.

ASSISTANT PROFESSOR, mechanical engineering. Four years' teaching, Naval Academy, principally thermodynamics; 10 years' practical engineering experience. M.S. degree. Me-226.

[1] All men listed hold some form of A.S.M.E. membership.

A TYPICAL MARDI GRAS FLOAT AT NEW ORLEANS

MECHANICAL ENGINEER, 37; employed. Four years' experience developing oxyacetylene and electric-welding apparatus; 7 years' experience on antifriction bearings. Widely experienced drafting and machine design. Excellent references. New York City preferred. Me-227.

AUTOMOTIVE DESIGNER, 21, single, B.S. in M.E. Experienced in internal-combustion engine thermodynamics and design. Will go anywhere. Available immediately. Me-228-3812-D-4-San Francisco.

PROFESSOR OF MECHANICAL ENGINEERING. Subjects: Heat, power, heating and ventilating, engineering laboratory. Experience both inside and outside academic circles. Available in fall of 1939. Me-229.

MECHANICAL ENGINEER, 37, married. Seven years' sales; 7 years' petroleum refining. Now employed as sales engineer and in charge of machinery installations. Prefers position in Diesel or lubrication engineering. Me-230-351-D-5-San Francisco.

POSITION WANTED. Designer of automatic machinery of all kinds, especially wire-forming and sheet-, ribbon-, or strip-metal. Machinery for secondary operations. Model or experimental machinery, inventive ability, years of experience. Me-231.

MECHANICAL ENGINEER, graduate in industrial engineering, Pratt Institute. Some experience in jig department of aircraft corporation; 1 year with service department of cash-register company. Me-232.

ENGINEER, 55, now employed. Technically trained in structural and mechanical engineering. Broad executive and production experience in marine shops, principally repair. Thoroughly posted on engineering materials. Spanish spoken. Me-233.

MECHANICAL AND ORDNANCE ENGINEER. Experience: Design, construction, testing and inspection of machine, semiautomatic and rapid-fire guns, sights, mounts, field carriages, limbers, ammunition, special machinery, and tools, jigs, and fixtures for manufacturing. Me-234.

PRODUCTION ENGINEER, capable assuming full responsibility for planning and scheduling, production and inventory control. Experienced also manufacturing costs, plant and property accounting. Available immediately. Location, eastern U. S. or Canada. Me-235.

PLANT ENGINEER, age 42, executive type. Broad experience in plant-maintenance, construction, and power-plant operation. Technical graduate in mechanical engineering. Available at once. Me-236.

CHIEF INDUSTRIAL ENGINEER, 16 years' wide experience industrial engineering, training, supervision, nonrigid, assembly, process industries. Thoroughly versed modern management. Aggressive. Congenial. Understands labor. Employed. Investigation invited. Available for progressive manufacturer. Me-237.

RESEARCH EXECUTIVE AND EDUCATOR, 41, married. Employee, promoted; must advance. Shop manufacturing, production, design, publishing, writing, 5 years' experience lecturing, teaching science; 7½ years' associate professor, Sc.D. Me-238.

MECHANICAL ENGINEER, graduate, 23 years old. High scholastic averages; shop and designing experience. Salary secondary to possible advancement. Me-239.

POSITIONS AVAILABLE

MECHANICAL ENGINEER to act as assistant to sales manager. Must have experience in stamping field, and be familiar with estimating and pricing. Experience in selling cold-rolled strip in New England desirable. Should have good personality, and be able to handle correspondence and other matters pertaining to sales in the absence of sales manager. Apply by letter. Location, New England. Y-3607.

GRADUATE MECHANICAL ENGINEER, 35–45, with at least 5 years' experience as works manager of metal-working plant having as part of its processes metal stamping, deep drawing, and polishing. Experience in nonferrous foundry work also desirable. Applicant must show successful record of accomplishment as works manager of company now in good standing. Apply by letter. Location, New England. Y-3608.

INDUSTRIAL ENGINEER with 8 to 10 years' experience. Must be able to set time standards and install wage incentive in plant now on day work. Ability to improve layout of plant equipment and to assist in installing standard costs is important. Experience in welding and contract-welding work combined with machine-design and machine-shop construction is essential. Apply by letter. Location, Pennsylvania. Y-3645.

MECHANICAL OR INDUSTRIAL ENGINEER, 30–40, with at least five years' experience in planning, scheduling, and costs in jobbing machine shops. Knowledge of wage-incentive plans is desirable and experience in machine shop is essential. Salary, $250–$350 a month. Apply by letter. Location, Pennsylvania. Y-3650.

MECHANICAL ENGINEER with experience in derrick and hoisting-machinery line, and also in steel fabricating. Will act as chief mechanical engineer in charge of small staff of draftsmen. Must also have sales ability. Apply by letter. Location, New York State. Y-3660.

RESEARCH ENGINEER with experience in drying problems and grinding machinery. Must have proper background and personality to conduct work and convince other departments of company of its merits. Salary, $4000–$5000 a year. Apply by letter. Location, Illinois. Y-3665-R-651C.

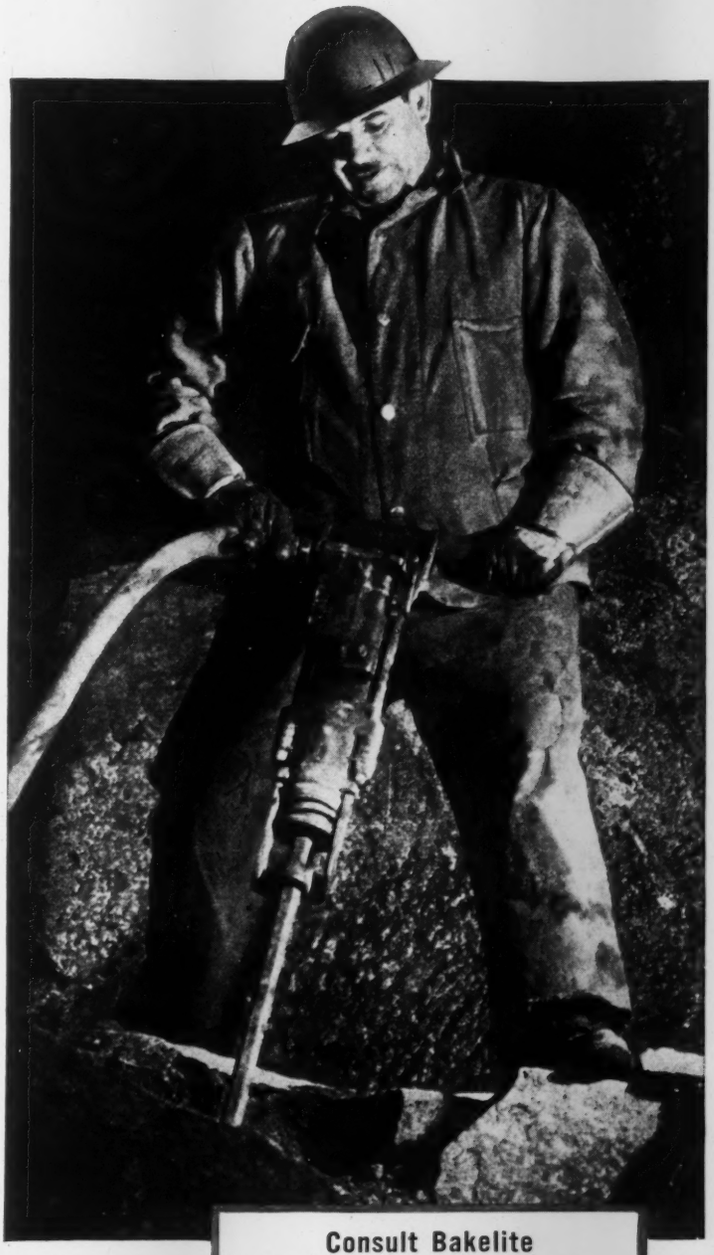
SHOP INSPECTOR for factory employing about 500. Must be accurate machinist and toolmaker, and have background of precision work. Able to organize and set up efficient inspection department, possess executive ability, and able to get along with coworkers and employees. Man who has resided in Middle West preferred. Apply by letter. Location, Middle West. Y-3676C.

CHIEF ENGINEER, not over 45, to operate

(*A.S.M.E. News continued on page 190*)

Shock-resistant Plastics with

Strength to Save a Life



LESS THAN ⅛-INCH THICK and weighing only 11 ounces, modern safety helmets made from Bakelite Laminated are sufficiently strong and tough to withstand the blows of crashing rocks —to protect miners and construction workers effectively against this ever-present menace.

For the development of these improved helmets, Mine Safety Appliance Company sought and found a material of unusual shock resistance at Bakelite Plastics Headquarters. With flexural strength of 20,000 lbs. per sq. in., and specific gravity of only 1.38, Bakelite Laminated fully meets this company's requirements.

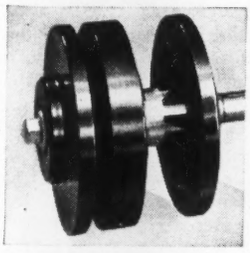
There are many other mechanical-design problems that may be solved with equal advantage through use of tough, enduring Bakelite plastics. In addition to various types of Bakelite Laminated, there are hundreds of Bakelite molding materials offering wide selection of impact and tensile strengths, heat and chemical resistance, transparent, translucent, and opaque decorative effects, and other useful characteristics.

Whenever you need plastic materials with unusual resistance to impact or other severe service conditions, consult Bakelite Headquarters *first.* It will save you time in selecting the proper plastic for the job. Write for Portfolio 32 of illustrated booklets containing A.S.T.M. data.

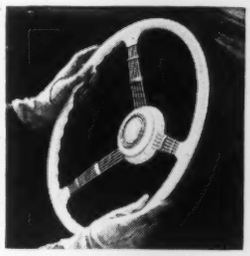
BAKELITE CORPORATION, 247 Park Ave., New York
Chicago: 43 East Ohio Street
BAKELITE CORPORATION OF CANADA, LTD., 163 Dufferin St., Toronto
West Coast: Electrical Specialty Co., Inc., San Francisco, Los Angeles, Seattle

BAKELITE

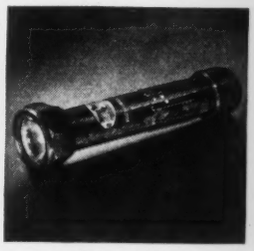
PLASTICS HEADQUARTERS



Speedmaster 6¾" variable speed pulleys of impact resistant Bakelite Molded.



Bakelite Cellulose-Acetate molding materials withstand the shocks, jars and abuse of automotive service.



Impact resistant Bakelite Molded furnishes ruggedness, lightweight, and moisture resistance in this flashlight made by Stewart R. Browne Mfg. Co.

Consult Bakelite Headquarters for Plastics

More than 2,000 plastic materials are available at this single, central source . . . phenolic, urea, cellulose-acetate and polystyrene plastics . . . transparent, translucent and opaque materials in all colors . . . many types with special resistance to impact, heat, chemicals or electric stress. Supplied in many forms including:

LAMINATED STOCK — BONDING RESINOIDS
MOLDING MATERIALS — SPECIAL CEMENTS
CAST RESINOIDS — BAKING-TYPE FINISHES

VISIT THE BAKELITE EXHIBIT, HALL OF INDUSTRIAL SCIENCE, NEW YORK WORLD'S FAIR 1939